Storm Water Management Program Plan

Honolulu International Airport

Section D: Permanent BMP Program

STATE OF HAWAII, DEPARTMENT OF TRANSPORTATION, AIRPORTS DIVISION
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NPDES Permit No. HIS000005

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Attachment D.2: Post-Construction BMP Handout
Attachment D.3: Retrofit Action Plan

1.0 INTRODUCTION

The Post-Construction Storm Water Management in New Development and Redevelopment Program (Permanent BMP Program) is complementary to the Construction Program in that permanent Best Management Practices (BMPs) may be incorporated into construction designs to prevent the discharge of pollutants after the project is completed. This Permanent BMP Program includes training and outreach to clarify requirements; plan review to ensure permanent BMPs have been included, where possible; permanent BMP standards that includes low impact development (LID); and tracking of inspection and maintenance data for permanent BMPs.

The purpose of permanent BMPs (Attachment D.1) is to retain storm water on-site, control the source of potential pollutants, and/or treat storm water that does enter the MS4.

DEFINITIONS:

Permanent BMP - Best Management Practice designed to improve water quality after construction is completed. Subcategories include:

- Low Impact Development
- Source Control
- Treatment

Low Impact Development (LID)- Site design that seeks to mimic predevelopment hydrology by minimizing disturbed areas and impervious cover and then infiltrating, storing, detaining, evapotranspirating, and/or biotreating storm water runoff close to its source.

Impervious Surface - Material that limits the infiltration of storm water, such as rooftops, runways, taxiways, parking lots, or paved areas.

1.1 Projects Requiring Permanent BMPs

Permanent BMPs will be considered for construction projects associated with both new development as well as redevelopment that meet one or more of the following criteria:

- Construction activities that result in land disturbance of one (1) acre or more.
- Construction projects less than one (1) acre that result in the installation of one or more of the following:
    - Steep earthen slopes (i.e. grade of 20 percent or more).
    - Parking lots and buildings adding 10,000 square feet or more of impervious area within 50’ of a surface water body.
    - Uncontained aircraft, vehicle, or equipment washing area.
    - Fueling area or petroleum storage that exceeds the regulatory threshold for Spill Prevention, Control, and Countermeasure (SPCC) plans in 40 CFR 112 (i.e. 1,320 gallons).
    - Modifying, replacing, or installing new MS4 drainage structures, as appropriate.

1.1.1 Exemptions

The following projects are exempt from submittal requirements and oversight under the Permanent BMP Program, but may still be observed by DOTA as a part of the construction program (Section C) and/or industrial and commercial activities program (Section F).

- Trenching and resurfacing associated with utility work.
- Resurfacing or replacement of damaged pavement.
- Discontinuous sites.
- Sites where storm water runoff does not ultimately discharge to a receiving water.
- Projects which return the area to pre-development runoff conditions.
- Sites where permanent BMPs may be prohibited due to aircraft safety concerns.
- Projects that do not meet the DOTA SWMPP definition of construction or are excluded under Section C, 1.1.1.

Designers may also provide other justification to the reason that permanent BMPs are not feasible at the site; however, these must be approved by the DOTA Environmental Engineer. Where exemptions are applied, Designers should review the Sustainable High Performance Guidelines to determine if additional pollution prevention measures may be required.

1.2 Roles and Responsibilities

Those parties with specific roles in regards to the Permanent BMP Program are included in Table 1.

TABLE 1: PERMANENT BMP PROGRAM ROLES AND RESPONSIBILITIES

Section	Title	Responsibilities
DOT	Director	• Approves DOTA Projects • Approves Enforcement
AIR-EE	Supervisor	• Provides Program Oversight • Tracks and Analyzes Program Data • Facilitates Training and Education
AIR-EE	Environmental Engineer*	• Conducts Plan Reviews • Coordinates with Involved Parties (Regulatory Agency, PM, CM, Designer, Contractor) • Distributes Outreach Material • Conducts Enforcement Actions • Maintains Permanent BMP Database
AIR-EE	Environmental Health Specialists*	• Conducts Permanent BMP Inspection for DOTA Sites • Verifies Permanent BMP Inspection and Maintenance for Tenant Sites (per Section F, Tenant Inspections) • Maintains Permanent BMP Database

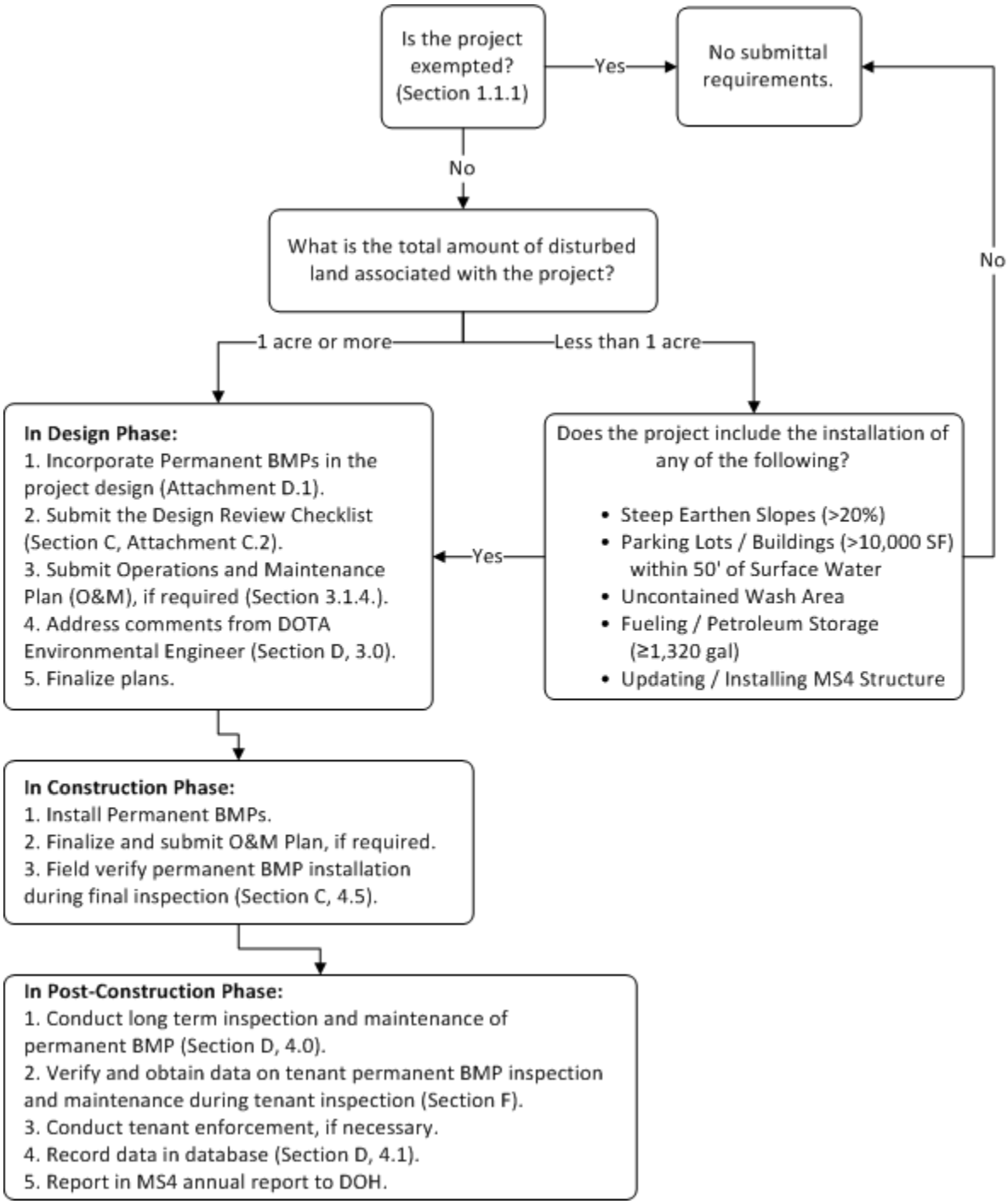
Section	Title	Responsibilities
AIR-E	Engineering Program Manager	• Oversight for DOTA Projects • Supports Enforcement
AIR-E	State Project Managers (SPM)	• Develops Construction Specifications that Include Permanent BMP Requirement • Manages DOTA Projects • Oversees Project Consultants and Contractors • Facilitates Plan Review with AIR-EE • Estimates Future O&M Costs for Permanent BMPs
Oahu District	Airport Manager	• Oversees TIP and DOTA Projects • Provides Final Approval for TIP • Supports Enforcement
AIR-OM	Maintenance Superintendent	• Oversees Permanent BMP Maintenance • Provides Maintenance / Inspection Data to AIR-EE
AIR-OME	State Project Managers (SPM)	• Oversees for TIP • Facilitates Plan Review with AIR-EE
	Tenants	• Submits Construction Plans for Approval • Facilitates Project Inclusion of Permanent BMPs • Addresses Comments from Plan Review • Facilitates Permanent BMP Maintenance • Provides Maintenance / Inspection Data to AIR-EE
	Designers	• Includes Permanent BMPs in Construction Plans, where applicable • Submits Documents for Plan Review and Addresses Comments
	Construction Managers (CM)	• Oversees the Installation of Permanent BMPs
	Contractors	• Installs Designated Permanent BMPs • Provides Information on Long-Term BMP Maintenance

*Note: Consultants may be used to fill roles where necessary.

2.0 PERMANENT BMP IMPLEMENTATION

Figure 1 details each component of the Permanent BMP Program and the associated requirements for quick reference.

FIGURE 1: PERMANENT BMP REQUIREMENTS



2.1 Training

DOTA requires that parties with Permanent BMP Program responsibilities (e.g. SPMs, CMs, Inspectors, Plan Reviewers, Designers, Contractors) to be trained annually. The training on permanent BMPs is conducted in conjunction with construction BMP training. The training includes information on the selection, design, installation, operation, and maintenance of temporary BMPs and permanent BMPs (including structural controls and LID practices). The training is further described in SWMPP Section A, 2.1.3 and the pertinent training video is available on the DOTA website:
http://hidot.hawaii.gov/airports/doing-business/engineering/environmental/construction-site-runoff-control-program/.

2.2 Education

DOTA's public education program is fully described in SWMPP Section A; however, DOTA has developed a Post-Construction BMPs handout (Attachment D.2) that includes information about the DOTA design process, permit requirements, and BMP design, installation, and maintenance. This handout was originally presented to participants in the Construction / Post-Construction classroom training and is available for download from the DOTA website.

3.0 PLAN REVIEW

As a part of the plan review process described in Section C, 3.0, DOTA will ensure that all required construction projects (refer to Section D, 1.1) have included permanent BMPs in their designs, where feasible. In the event that permanent BMPs are not feasible, specific documentation that demonstrates this fact will be submitted for approval to the DOTA Environmental Engineer. Plans will be considered approved when all comments from the DOTA Environmental Engineer have been addressed.

3.1 Permanent BMP Design Criteria

In addition to standard engineering design practices, Project Designers must conduct an evaluation of the project site conditions and planned future use in order to determine which permanent BMPs would be the most effective. The Designer must also provide an estimate of future operational and maintenance costs for proposed permanent BMPs as a part of the plan review process. The basic steps in the decision making process are presented in Figure 2.

FIGURE 2: PERMANENT BMP SELECTION PROCESS

3.1.1 Pollutants of Concern

Designers should identify anticipated pollutants of concern in accordance with the following:

- Planned Activities.
- Planned Site Design.
- HNL MS4 NPDES Requirements.
    - SWMPP Section E, Trash Reduction Plan.
- State CWA Section 303(d) List for Receiving Water Impairments.

The following minimum pollutants of concern should be considered based on the project site's ultimate receiving water in addition to anticipated site activities and design.

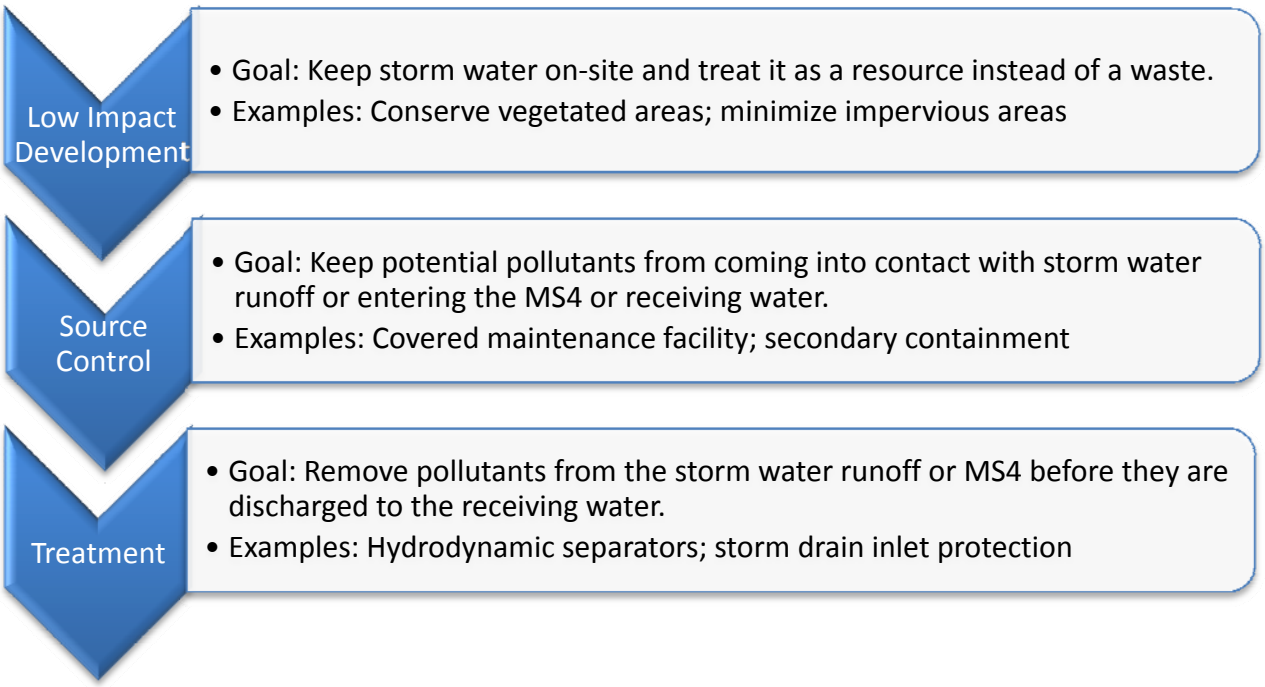
- Projects Discharging to Keehi Lagoon:
    - Trash.
    - Bacteria (Enterococci).
    - Nutrients (Total Nitrogen, Nitrate + Nitrite, Total Phosphorus).
    - Sediment (Turbidity, Total Suspended Solids).
    - Chlorophyll a.
- Projects Discharging to Mamala Bay, Ahua Pond, Kaloaloa Canal, Manuwai Canal:
    - Trash.

3.1.2 Candidate BMPs

The Permanent BMP Manual (Attachment D.1) includes several categories of permanent BMPs to address the potential pollutants identified in the previous step. However, Designers may also include BMPs not listed in the manual provided sufficient information about the design, performance, requirements, and maintenance is included with the construction plans for the DOTA Environmental Engineer to review.

The DOTA has developed a preferred list of permanent BMPs, which is included in the Permanent BMP Manual. Preferred BMPs should be considered first for a project site and if infeasible, other permanent BMPs may be selected based on the order of preference presented in Figure 3.

FIGURE 3: PERMANENT BMP CATEGORIES IN ORDER OF PREFERENCE



The DOTA has developed *Sustainable High Performance Guidelines* that may be applied to project sites independent of the permanent BMP requirement. These guidelines provide standards for sustainability that may also meet the objectives of permanent BMPs. Designers should review the appropriate documents on the DOTA website for more information: http://hidot.hawaii.gov/airports/doing-business/engineering/sustainabledota/.

3.1.3 BMP Sizing Criteria

DOTA requires specific criteria for permanent BMPs for both volume-based and flow-based BMP designs. These criteria are in alignment with the City and County of Honolulu (CCH) *Rules Relating to Storm Water Standards*, which may be used as an additional reference.

A. Volume-Based Designs

Volume based designs include those that will hold a set volume of runoff such as infiltration basins/trenches, evaporation ponds, underground detention/infiltration systems, dry wells, permeable pavement, green roofs, vegetated bio-filters, and sand filters.

The design must hold **1 inch of runoff** and shall be sized based on the following equations:

$$WQV = PCA \times 3630$$

Where:
- WQV = water quality volume (cubic feet)
- P = design storm runoff depth (inches) = 1 inch
- C = volumetric runoff coefficient
- A = total drainage area (acres)

$$C = 0.05+0.009(I)$$

Where:
- C = volumetric runoff coefficient
- I = percent of impervious cover, expressed as a percentage

B. Flow-Based Designs

Flow-based designs include those that will move storm water through a system that also provides for the removal of potential pollutants. Examples of flow-based designs include vegetated swales, vegetated filer strips, and manufactured treatment devices.

The design must be able to accommodate a peak rainfall intensity of **0.4 inches per hour**, based on the following equations:

$$WQF = CIA$$

Where:
- WQF = water quality flow rate (cubic feet per second)
- C = runoff coefficient (Table 1)
- I = peak rainfall intensity (inches per hour) = 0.4
- A = total drainage area (acres)

TABLE 2: RUNOFF COEFFICIENTS

Type of Drainage Area	Runoff Coefficient
Light Industrial	0.5 – 0.8
Heavy Industrial	0.6 – 0.9
Roofs	0.75 – 0.95
Asphalt and Concrete Pavement	0.70 – 0.95
Unimproved Areas	0.1 – 0.3

Note: Data source from City and County of Honolulu, *Rules Relating to Storm Water Standards.*

3.1.4 Plan for BMP Maintenance

The Designer must identify BMP maintenance arrangements for selected permanent BMPs during the design phase. An Operations and Maintenance (O&M) Plan will be developed in most cases to document these requirements. The O&M plan will specify responsibility for long-term inspection and maintenance of the BMP. For DOTA projects, DOTA will be responsible for long-term maintenance. For TIP, tenants will be responsible for long-term maintenance. Mechanisms used to assign responsibility for maintenance to tenants may include:

- Lease Language.
- Covenants.
- Maintenance Agreements.
- Conditional Use Permits.
- Other Legal Agreements.

3.2 Retrofit Action Plan

The January 2015 *Retrofit Action Plan* (Attachment D.3) includes an updated list of sites that may be redeveloped to include permanent BMPs. Where possible, Designers should include these identified permanent BMPs in their redevelopment projects.

4.0 INSPECTION AND MAINTENANCE

All Low Impact Development and Treatment Permanent BMPs are to be inspected annually to ensure they are functioning properly and that maintenance is performed as necessary. These inspections will verify proper operation in accordance with the site O&M manual or the Permanent BMP Manual (Attachment D.1). For DOTA owned BMPs, District Maintenance Superintendent will ensure that inspection and maintenance data is submitted to AIR-EE for inclusion in the annual report. For Tenant owned BMPs, AIR-EE will obtain maintenance data during tenant inspections (Section F).

4.1 BMP, Operation and Maintenance, and Inspection Database

All permanent BMPs are tracked in the Enviance database or similar system and in addition to the standard identification information, the following information is included:

- Permanent BMP Category (i.e. LID, Source Control, Treatment).
- Latitude / Longitude.
- O&M Requirements.
- Reference Location for BMP Photographs.
- Date of Inspection and/or Maintenance.

5.0 EVALUATION METHODS

The Permanent BMP Program will be evaluated based on specific metrics included below to determine its effectiveness. Specifically, measurable standards, milestones, and monitoring parameters are included in Table 3 from the MS4 NPDES permit. All final tallies of progress on permanent BMP metrics will be included in the annual report to the DOH and EPA.

TABLE 3: PERMANENT BMP PROGRAM MEASURABLE STANDARDS, MILESTONES, AND MONITORING

SWMPP Reference	BMP / Task	Measurable Standard / Milestones	Monitoring Effectiveness	Timeframe
Section D, 3.1.2 & Attach D.1	Permanent BMP Manual	Revise the Permanent BMP Manual to include LID requirements.	Confirmation: • Revision completed.	4/14/16
Section D, 3.0 & Attach C.5	Plan Review	Conduct construction plan reviews to ensure permanent BMPs and their long-term maintenance requirements are included in the design for applicable projects.	Tabulation: • # of projects reviewed.	Annual
Section D, 4.1	Database	Track inspection and maintenance of permanent BMPs in Enviance or similar system. • Inspect each LID and treatment BMP annually. • Conduct maintenance on DOTA permanent BMPs, when necessary.	Confirmation: • All LID and treatment BMPs inspected and maintained as necessary.	Annual
			Tabulation: • # of BMPs by permanent BMP category.	Annual
			Tabulation: • # of inspections.	Annual
			Tabulation: • # of maintenance events.	Annual
Section A, 2.1.3 & Section D, 2.1	Training	Provide annual training to targeted groups in accordance with SWMPP Section A, 2.1.3.	Tabulation: • # of parties trained on permanent BMPs.	Annual

SWMPP Reference	BMP / Task	Measurable Standard / Milestones	Monitoring Effectiveness	Timeframe
Section D, 2.2, Attach D.2.	Education	Distribute Post-Construction BMP Handout.	Confirmation: • Educational material developed.	3/13/19
			Tabulation: • # of handouts distributed.	Annual

In Table 4, the DOTA has set goals for the Permanent BMP Program above the minimum control measures listed in Table 3. These goals provide a more complete evaluation of the effectiveness of program activities and will be used to make changes to the program where necessary. These goals will be reported separately in the annual report and may or may not be met depending upon several variables, including available manpower and funding for a particular year.

TABLE 4: PERMANENT BMP PROGRAM GOALS AND EVALUATION METHODS

SWMPP Reference	Activity	Outcomes / Goals	Evaluation Method	Outcome Category	Timeframe
Section D, 3.0 & Attach C.5	Plan Review	Conduct construction plan reviews to ensure permanent BMPs are included in the design for applicable projects. • 5% increase in LID designs for finalized projects as compared to source control and treatment BMP designs.	Tabulation: • Baseline Establishment: # of permanent BMP designs by category.	1	6/30/16
			Tabulation: • % increase in # of LID designs.	2-3	3/13/19

Attachment D.1

Permanent BMP Manual

Post- Construction Best Management Practices

Storm Water Permanent BMP Manual

STATE OF HAWAII, DEPARTMENT OF TRANSPORTATION, AIRPORTS DIVISION
400 Rodgers Boulevard, Suite 700
Honolulu, Hawaii 96819-1880

June 2015

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PC17: Green Parking	32		X
PC18: Alternative Pavers	33		X
PC19: Bioretention	34		X
PC20: Sand Filters	36		X
PC21: Oil Water Separator	41		X
PC22: Continuous Deflective Separation (CDS)	42		X
PC23: Storm Drain Inlet Protection	43		X
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PC31: Material Storage Area Design	56	X	

Note: SC = Source Control BMP; TR = Storm Water Treatment BMP

Introduction

The Honolulu International Airport (HNL) Storm Water Management Program Plan (SWMPP), Section D Post-Construction Storm Water Management (Section D) requires that specified construction projects include permanent Best Management Practices (BMPs). DOTA considers permanent BMPs as further described in the following categories based on priority:

1. Low Impact Development Site Design Strategies (LID)
2. Source Control BMPs (Source Control)
3. Storm Water Treatment BMPs (Treatment)

This manual is designed to serve as guidance on the selection, installation, and maintenance of permanent BMPs; however, Designers may also include BMPs not listed in this manual provided it is approved by the DOTA Environmental Engineer.

BMP Selection

The DOTA has developed a preferred list of permanent BMPs, which is included in the Permanent BMP Manual. Preferred BMPs should be considered first for a project site and if infeasible, other permanent BMPs may be selected based on the order of preference presented in the chart below. Note: A single BMP may address goals listed in multiple categories.

Low Impact Development

- Goal: Keep storm water on-site and treat it as a resource instead of a waste.
- Preferred BMPs:
  - Underground Detention Basin (PC24) - recent project Mauka Concourse and Consolidated Rental Car Facility.
  - Pervious Pavement (PC18) - recent project Elliott Street Parking Lot.

Source Control

- Goal: Keep potential pollutants from coming into contact with storm water runoff or entering the MS4 or receiving water.
- Preferred BMPs:
  - Covered Maintenance Facility (PC27) - recent project Hawaiian Hangar.
  - Secondary Containment (PC31) - recent project Aloha Hangar.

Treatment

- Goal: Remove pollutants from the storm water runoff or MS4 before they are discharged to the receiving water.
- Preferred BMPs:
  - Hydrodynamic Separators (PC22) - recent projects Ewa Hardstands, DH Commuter Terminal, Consolidated Rental Car Facility.
  - Storm Drain Inlet Protection (PC23) - recent project catch basin 7572.

BMPs should be sized in accordance with Section D (i.e. Volume-Based = 1 inch; Flow-Based = 0.4 inch/hour) and selected based on potential pollutants of concern. The following minimum pollutants of concern should be considered based on the project site's ultimate receiving water in addition to anticipated site activities and design.

- Projects Discharging to Keehi Lagoon:
  - Trash.
  - Bacteria (Enterococci).
  - Nutrients (Total Nitrogen, Nitrate + Nitrite, Total Phosphorus).
  - Sediment (Turbidity, Total Suspended Solids).
  - Chlorophyll a.
- Project Discharging to Mamala Bay, Ahua Pond, Kaloaloa Canal, Manuwai Canal:
  - Trash.

BMP	Nutrients	Sediment	Trash	Bacteria	Pesticides	Oil & Grease	Metals	Organic Compounds
Infiltration Basin	H	H	H	H	H	H	H	H
Infiltration Trench	H	H	H	H	H	H	H	H
Subsurface Infiltration	H	H	H	H	H	H	H	H
Dry Well	H	H	H	H	H	H	H	H
Bioretention Basin	H	H	H	H	H	H	H	H
Permeable Pavement	H	H	L	H	H	H	H	H
Green Roof	M	H	H	M	M	H	M	M
Vegetated Bio-Filter	M	H	H	M	U	H	H	H
Enhanced Swale	M	H	H	U	U	M	M	U
Downspout Disconnection	L	M	M	M	U	M	M	U
Vegetated Swale	L	M	L	L	U	M	M	U
Vegetated Buffer Strip	L	M	M	L	U	M	M	M
Harvesting / Reuse	H	H	L	H	H	H	H	H
Detention Basin	L	M	H	L	U	M	L/M	U
Manufactured Treatment Device	L	M/H	H	L	L	M/H	L	L
Sand Filter	L/M	H	H	M	U	H	M/H	M/H

Note: H= High, M = Medium, L = Low, U = Unknown

*Reference from City and County of Honolulu, *Storm Water BMP Guide*

Permanent Best Management Practices
Low Impact Development

LID refers to storm water management practices which seek to mimic predevelopment hydrology by minimizing disturbed areas and impervious cover and then infiltrating, storing, detaining, evapotranspiring, and/or biotreating storm water runoff close to its source. LID employs principles that manage storm water as a resource, rather than a waste product.

In addition to having the overall concepts in mind during the design phase, several permanent BMPs included in the manual also meet LID objectives (refer to text box on the right).

PERMANENT BMPS THAT ALSO MEET LID OBJECTIVES:

- **PC1 Preserving Vegetation**
- **PC2 Seeding and Planting**
- **PC3 Mulching**
- **PC5 Vegetated Buffer Strips**
- **PC6 Vegetated Swales**
- **PC7 Slope Drains**
- **PC8 Diversion Ditches / Berms**
- **PC13 Infiltration Trenches**
- **PC14 Retention Basins**
- **PC15 Green Roofs**
- **PC16 Alternative Wetlands**
- **PC17 Green Parking**
- **PC18 Alternative Pavers**
- **PC19 Bioretention**
- **PC24 Underground Detention**
- **PC25 Storm Water Harvesting**

Objective #1: Minimize Disturbed Areas

The conservation of vegetated areas as a part of development and redevelopment projects provides various storm water benefits including the interception of runoff, evapotranspiration, and infiltration. Managing sites in this manner allows for reduced runoff volume and velocity provided that soil types permit infiltration and are prevented from becoming compacted. Further, the conservation of vegetation and associated soils may also assist in removing some of the pollutants through filtration. In particular, consider preserving vegetation in the following areas: wetlands, natural flow paths, steep slopes, mature trees, and areas near surface water bodies. For more information refer to PC1: Preservation of Existing Vegetation.

Objective #2: Minimize Impervious Areas

Impervious areas are those that limit the infiltration of storm water, such as rooftops, runways, taxiways, parking lots, or other paved areas. Storm water runoff from impervious areas has an increased volume, velocity, and discharge duration than a vegetated area of the same size. In association with the increase in flow, there is an increase in pollutants that may be carried to the MS4 or receiving waters. Designers should seek to eliminate or reduce impervious areas wherever possible. Some examples may include reducing sidewalk widths, incorporating shared driveways and parking areas, redesigning parking lots to be more compact (PC17), installing green roofs (PC15), or using alternative pavers (PC18).

Objective #3: Managing Storm Water Near the Source

Due to the nature of operations at the airport, safety concerns from the Federal Aviation Administration, and space available at HNL, it may be difficult for Designers to conserve vegetation or minimize impervious areas. However, it may still be feasible to manage storm water on or near the site. This management of storm water may include designs directing storm water to BMPs that allow for infiltration, storage, detention, evapotranspiration, and/or treatment such as rain gardens or other bioretention (PC19), vegetated swales (PC5, PC6), retention basins (PC14), underground detention basins (PC24), or a rainwater harvesting devices (PC25).

Permanent Best Management Practices
PC1: Preservation of Existing Vegetation

Description
Preservation of existing vegetation involves protecting desirable plants and trees in any area subject to land-disturbing activities. The primary function of existing vegetation preservation is to provide an effective form of soil stabilization control, as well as watershed protection, landscape beautification, dust control, pollution control, noise reduction, and shade.

Potential Pollutant Source Controlled
The primary pollutants managed by this BMP are sediment and debris; however, vegetation may also filter a variety of other potential pollutants, such as nutrients, metals, bacteria, oil & grease, organic compounds, etc.

Limitations
Protection of existing vegetation requires planning, and may limit the area available for construction activities. Additionally, if land costs are high, it may not be practical to preserve areas of existing vegetation for a given project unless required by regulation. In this case, it may be appropriate to evaluate the existing vegetation for species type for use in landscaping plans.

Practice		
☐	PC 1.1	Preservation of existing vegetation shall be practiced in the following locations: • Areas on a site where no construction activity is planned or will occur at a later date. • Sensitive areas where natural vegetation exists and should be preserved, such as on steep slopes, watercourses, and building sites in wooded areas. • Within and as a buffer to areas where federal, state, or local government regulations require preservation, such as delineated wetlands, marshes, areas or protected trees, etc.
PLANNING:		
☐	PC 1.2	Preservation of vegetation on a site is to be planned before any site disturbance begins.
☐	PC 1.3	Decisions on which vegetation to save is to be based on the following considerations: • Native Hawaiian or endangered plants • Life expectancy • Health and disease susceptibility • Structural integrity • Aesthetic values • Comfort relative to site temperature variation and wind • Wildlife benefits • Adaptability to the proposed project • Survival needs of the vegetation • Relationship to other vegetation
☐	PC 1.4	All vegetation to be retained is to be delineated and identified (species and size) on the site plan and tagged in the field.
☐	PC 1.5	Critical areas, such as floodplains, steep slopes, and wetlands, are to be left in their initial condition unless disturbance is unavoidable.
☐	PC 1.6	Temporary roadways, utilities, material storage, and crew parking are to be located to minimize damage to shrub and tree stands, following contours to reduce cutting and filling.

☐	PC 1.7	For retention of existing trees in paved areas, at least 5 feet of ungraded ground beyond the drip line is to be retained to help ensure tree survival. Keep equipment away from trees to avoid damage.
☐	PC 1.8	Wind damage can result from exposure of vegetation to increased wind velocities, therefore this must be considered when removing adjacent vegetation.
☐	PC 1.9	Soil stabilization measures are to be located at the limits of clearing to prevent sediment deposition within the area where vegetation is being preserved.
☐	PC 1.10	Plans shall include the maintenance of existing grade around vegetation to be preserved. Obtain recommendations from a qualified, licensed landscape architect or certified arborist prior to altering grades around existing vegetation.
☐	PC 1.11	Plans for tree preservation are to include protection from the following: • Compaction of the soil within the drip line of a tree, which can block off air and water from the roots. • Changes in soil chemistry that can result from spillage of chemicals or improper waste disposal.
TIMING:		
☐	PC 1.12	Preservation of existing vegetation needs to be planned during the design stages by the design engineer before any site disturbance begins.
☐	PC 1.13	No vegetation is to be destroyed or altered until the design of roads, buildings, and utility systems is finalized.
TREE AND VEGETATION MARKING AND PROTECTION:		
☐	PC 1.14	Within 40 feet of a proposed building or excavation, retained trees shall be protected by fencing: • Board fencing: 4-inch posts protruding 4 feet above ground. • Cord fencing: 2-inch posts protruding 4 feet above ground with two rows of cord at least 0.25 inch thick between posts. • Plastic fencing: 3-feet high orange polyethylene webbing secured to metal posts. • Tree buffer zone: Trees must be a maximum of 6 feet apart surrounding clearing limits. • Tree wrapping: Tree to be protected is wrapped with burlap and 2-inch studs wired vertically, no more than 2-inches apart encircling the truck to a height of 5 feet.
☐	PC 1.15	An earth berm may be constructed at the clearing limits for vegetation only if its presence does not conflict with drainage patterns.
☐	PC 1.16	If ground level must be raised around protected trees construct a tree well. Consult a qualified, licensed landscape architect or certified arborist concerning the method of constructing a tree well.
☐	PC 1.17	If the grade is being lowered, trees can be protected by constructing a surrounding tree wall of large stones, bricks, or concrete blocks filled with topsoil.
TRENCHING AND TUNNELING:		
☐	PC 1.18	All requirements of the utility system owner must be met. Root barriers around the tree or concrete jacketing of the utility line may be required.
☐	PC 1.19	The tunnel shall be at least 18 inches below the ground surface, and not below the tree center to minimize impact on the roots.
☐	PC 1.20	Roots shall not be left exposed to air; they shall be covered with soils as soon as possible, protected, and kept moistened with wet burlap or peat moss until the tunnel can be built.
☐	PC 1.21	The ends of damaged or cut roots are to be cut off cleanly and protected by painting them with a tree-wound dressing, as recommended by a certified arborist.
☐	PC 1.22	Trenches and tunnels are to be filled as soon as possible. Careful filling and tamping will eliminate air spaces in the soil.

☐	PC 1.23	To induce and develop root growth, peat moss can be added to the fill material.
☐	PC 1.24	Trees shall be mulched and fertilized to conserve moisture, and to stimulate new root growth.
☐	PC 1.25	Remove any trees intended for retention if those trees are damaged seriously enough to affect their survival. If replacement is desired, the new tree shall be of similar species, and shall be of balled and burlapped nursery stock at least 2 inch caliper.
MAINTENANCE AND INSPECTION:		
☐	PC 1.26	During construction, the limits of disturbance are to remain clearly marked at all times. During the final cleanup and landscaping, fences, and barriers are to be removed last.
☐	PC 1.27	Any damage to the canopy, trunk, or root system of a retained tree during maintenance is to be repaired immediately.
☐	PC 1.28	Soil that has been compacted over a tree's root zone is to be aerated by punching holes 12 inches deep with an iron bar, and moving the bar back and forth until the soil is loosened. Holes are to be placed 18 inches apart throughout the area of compacted soil under the tree canopy.
☐	PC 1.29	Damaged roots are to be immediately cut cleanly. The cuts are to be painted with a tree-wound dressing and moist soil or soil amendments shall be spread over the area. A certified arborist shall be consulted regarding specific methods and materials.
☐	PC 1.30	If bark damage occurs, all loosened bark is to be cut back into the undamaged area, with the cut tapered at the top and bottom, and drainage provided at the base of the wound. Cutting of the undamaged area shall be minimized.
☐	PC 1.31	Serious tree injuries are to be attended to by a certified arborist, forester, or tree specialist.
☐	PC 1.32	Stressed or damaged broadleaf trees are to be fertilized to aid recovery.
☐	PC 1.33	Trees are to be fertilized in the late fall or early spring.
☐	PC 1.34	Fertilizer is to be applied in accordance with label instruction to the soil over the feeder roots, but never closer than 3 feet to the trunk. For conifers, which have extended root systems, the fertilized area is to be increased by one-fourth of the canopy area.

Permanent Best Management Practices
PC2: Permanent Seeding and Planting

Description
Permanent seeding and planting is the process of establishing a perennial vegetative cover on areas that have been disturbed by construction or maintenance activities or are otherwise subject to erosion. Permanent vegetation shall be self-sustaining, need low maintenance, and be compatible with the surrounding environment.

The primary functions of permanent seeding and planting are to:

- Reduce erosion by slowing runoff velocities and raindrop impact.
- Enhance infiltration and transpiration.
- Trap sediment and other particulates.
- Improve long-term aesthetics.

Potential Pollutant Source Controlled
The primary pollutants managed by this BMP are sediment and debris; however, vegetation may also filter a variety of other potential pollutants, such as nutrients, metals, bacteria, oil & grease, organic compounds, etc.

Limitations
If the site is susceptible to erosion, additional control measures may be necessary during seeding and planting in order to establish permanent vegetation.

Practice		
☐	PC 2.1	The site shall first be evaluated to select the appropriate vegetation and planting strategy, considering the following: • Soil type and condition • Site topography • Climate and season • Types of vegetation suited to the site • Maintenance concerns • Aesthetic considerations • Water, fertilizer, and herbicide requirements
☐	PC 2.2	Strip and stockpile topsoil. Use stockpiled materials in the surface preparation prior to seeding operations.
☐	PC 2.3	Apply fertilizer, lime, or other soil amendments as indicated by soil testing.
☐	PC 2.4	Roughen the slope or area to be seeded by plowing, disking, or raking to a depth of 6 inches, with the furrows trending along the contours.
☐	PC 2.5	Plant the seed using broadcast seeding, seed drilling, or hydraulic application of seed, as appropriate.
☐	PC 2.6	Apply a protective mulch to keep the seed in place and control soil moisture and temperature until the seed germinates and grows.
☐	PC 2.7	Irrigate the seed as needed based on rainfall conditions.
☐	PC 2.8	To conform to Hawaii Department of Agriculture's rules and regulations each seed bag is to be delivered to the site seal and clearly marked as to species, purity, percent germination, dealer's guarantee, and dates of test. The packaging will be labeled Pure Live Seed (PLS) contained.
☐	PC 2.9	Follow-up applications of see and fertilizer shall be made to cover weak or damaged areas.
☐	PC 2.10	If area is dry, new vegetation should be provided with supplemental water until established.
☐	PC 2.11	Cutting or mowing grasses will encourage the establishment and spread of the grass.
☐	PC 2.12	All seeded areas are to be inspected for failures and reseeded, fertilized, and mulched as needed, using half the original application rates.

Permanent Best Management Practices
PC3: Mulching

Description
Mulching is the process of applying loose bulk materials to the soil surface as a permanent or temporary cover. Common types of mulch are: green material, hydraulic matrices, hydraulic mulches made from recycled paper or wood fiber, stone and aggregate, vegetable fibers (hay or straw), and wood/bark chips. The primary function of mulching is to reduce erosion by protecting bare soil from rainfall impact, increasing infiltration, and reducing runoff. Mulches are also generally used to compliment seeding and vegetation establishment techniques.

Potential Pollutant Source Controlled
The primary pollutant managed by this BMP is sediment.

Limitations
- Organic mulches are not permanent erosion control measures.
- Vegetable fibers, such as hay or straw, require three-step machinery and are labor intensive during installation. For application with straw blowers, areas for treatment must be within 150 feet of a road.
- Green material is not always commercially available and has poor erosion control.
- Wood/Bark chips have poor erosion control and are not effective on steep slopes. Upon decomposition, the chips draw nitrogen from the soil; therefore, application must be augmented with a high-nitrogen fertilizer.
- Hydraulic Mulches (made from recycled paper) present a potential problem in environmentally sensitive areas due to residual inks and the short fibers limit erosion control.
- Hydraulic Mulches (made from wood fiber) have limited erosion control and do little to moderate moisture and temperature in soils.
- Hydraulic Matrices can be applied to any slope and prevent erosion control. They cannot be applied during, before, or after rain and require at least 24 hours drying time.

Practice		
☐	PC 3.1	Criteria for choosing the appropriate type of mulch: • Cost – material, preparation, and installation cost • Effectiveness – reduction of erosion, flow velocity, and runoff • Acceptability – environmental compatibility, visual impact, institutional acceptability • Vegetation Enhancement – native plant compatibility, germination rate, growth grate, moisture retention, temperature modification, open space/coverage, nutrient uptake. • Installation – durability, longevity, ease of installation, safety • Operation and Maintenance – maintenance frequency, need for fertilization or irrigation.
VEGETABLE FIBER MULCHING:		
☐	PC 3.2	Apply seed and fertilizer to the bare soil.
☐	PC 3.3	Apply loose hay or straw over the top of seed/fertilizer at a rate of 2 tons per acre either by machine or by hand distribution.
☐	PC 3.4	The mulch must be evenly distributed on the soil surface so that 80% to 90% of the ground is covered.
☐	PC 3.5	Maximum fiber length shall be maintained and average fiber length shall be greater than 6 inches.
☐	PC 3.6	Anchor the mulch in place by using a tackifier, netting, or "punch" it into the soil mechanically.
☐	PC 3.7	"Punching" straw of hay into the soil can be accomplished with spade or shovel on small areas. On slopes use a "crimper" (a mechanical knife-blade roller). On steep slopes use plastic netting or jute held in place with wire staples, geotextile pins, or wooden stakes.

GREEN MATERIAL MULCHING:		
☐	PC 3.8	Recycle vegetation trimmings as a temporary ground cover with or without seeding.
☐	PC 3.9	The green material is to be evenly distributed on a site to a depth of not more than 4 inches.
☐	PC 3.10	Anchoring green material in place with a tackifier is necessary on steep slopes and in areas where overland sheet flow is anticipated.
WOOD/BARK CHIP MULCHING:		
☐	PC 3.11	Soils must be tested before application and a minimum of 12 pounds nitrogen per ton of mulch must be added to prevent nutrient deficiency in plants.
☐	PC 3.12	Wood/bark chips are not suitable for steep slopes; use shredded wood/bark if necessary.
☐	PC 3.13	The mulch shall be distributed by hand evenly across the soil surface to a depth of 2 to 3 inches.
HYDRAULIC MULCHING:		
☐	PC 3.14	Mix recycled paper or wood fiber in a hydraulic application machine (hydroseeder) and applied as liquid slurry, which contains the recommended rates of seed and fertilizer for the site.
☐	PC 3.15	Must use 100% wood fiber with the following specifications: • Moisture content (total weight basis) not to exceed 12% ± 3%. • Organic matter content (oven dry weight basis) = 99.3% minimum. • Inorganic matter (ash) content (oven dried basis) = 0.7% maximum. • pH = 4.9 ± 10% for a 3% water slurry. • Water holding capacity (oven dried basis) minimum 1.2 gallons per pound of fiber.
HYDRAULIC MATRICES:		
☐	PC 3.16	Use hydraulic slurry composed of wood fiber, paper fiber, or a combination of the two held together by a binder system. A typical mixture applied on a per acre basis is as follows: • 500 pounds per acre wood fiber mulch. • 1,000 pounds per acre recycled paper mulch. • 55 gallons per acre acrylic copolymer with a minimum of 55% solids content.
BONDED FIBER MATRIX (BFM):		
☐	PC 3.17	The BFM shall be a hydraulic matrix which, when applied and upon drying, adheres to the soil to form a 100% cover which is biodegradable, promotes vegetation, and prevents soil erosion.
☐	PC 3.18	The BFM shall be comprised of long strand, thermally produced wood fibers (>88% of total volume by weight) held together by organic tackifiers (10%) and mineral bonding agents (<2%), which upon drying become insoluble and non-dispersible.
☐	PC 3.19	The matrix shall have a minimum water holding capacity of 1.2 gallons per pound matrix.
☐	PC 3.20	The matrix shall have no germination or growth inhibiting factors and shall not form a water insensitive crust.
☐	PC 3.21	The BFM shall be applied at rates from 3,000 to 4,000 pounds per acre based on the manufacturer's recommendation by an applicator trained and certified by the manufacturer.
☐	PC 3.22	The BFM shall not be applied immediately before, during, or immediately after rainfall, so that the matrix will have an opportunity to dry for 24 hours after installation.
☐	PC 3.23	Replace mulch when bare soil is visible beneath plants in more than 75% of the area. Inspect all such planting areas every 8 to 10 months.

Permanent Best Management Practices
PC4: Geotextiles, Mats, and Erosion Control Blankets

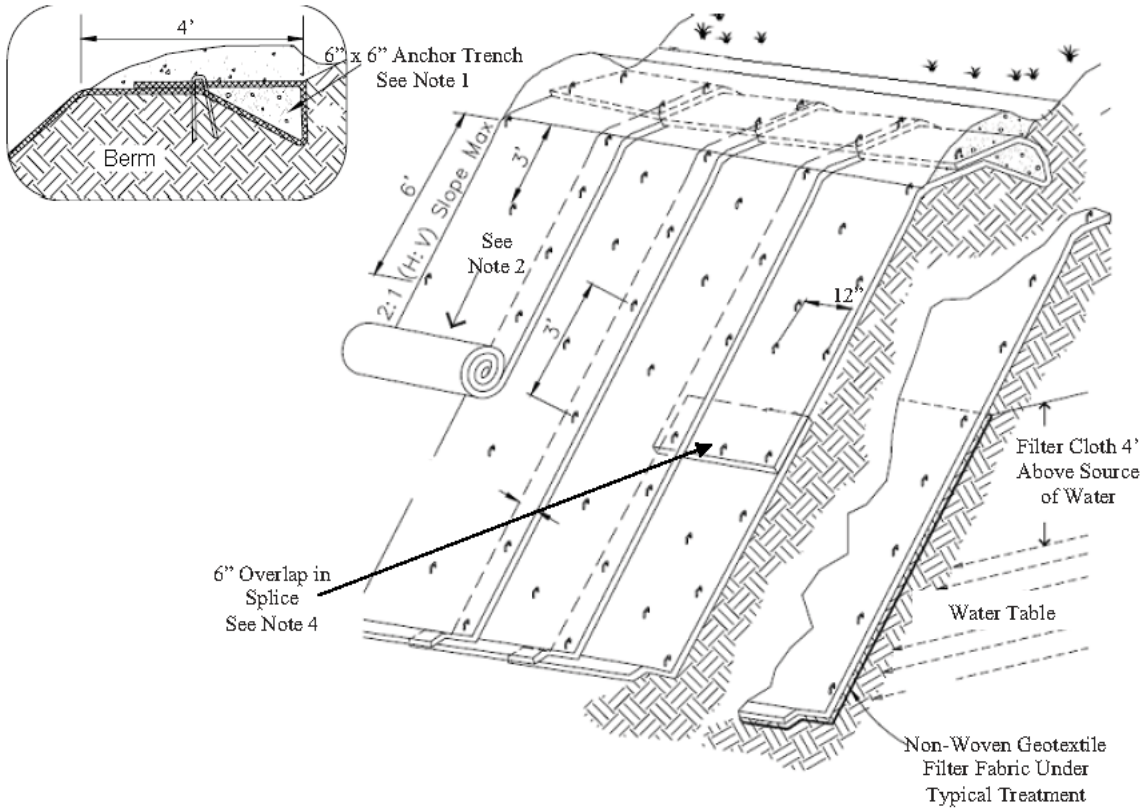
Description
Matting made of natural or synthetic material is used to temporarily or permanently stabilize soil. These products are to be considered at any sites where disturbed soils must be stabilized.

Potential Pollutant Source Controlled
The primary pollutant managed by this BMP is sediment.

Limitations
Blankets and mats are typically more expensive than other erosion control measures, primarily due to labor costs. Blankets and mats are generally not suitable for excessively rocky sites or areas where the final vegetation will be mowed (since stapes and netting can catch in mowers).

Practice		
SITE PREPARATION:		
☐	PC 4.1	Proper site preparation is essential to ensure complete contact of the blanket or matting with the soil.
☐	PC 4.2	Grade and shape the area of installation.
☐	PC 4.3	Remove all rocks, clods, vegetation or other obstructions so that the installed blankets or mats will have complete, direct contact with the soil.
☐	PC 4.4	Prepare seedbed by loosening 2 to 3 inches of topsoil.
☐	PC 4.5	Incorporate soil amendments, such as lime and fertilizer, as indicated by soil testing, the seeding plan, and manufacturer's recommendations.
☐	PC 4.6	Seed the area before blanket installation for erosion control and revegetation.
☐	PC 4.7	All mats and blankets should be anchored to the ground with sufficient penetration to resist pullout, generally 6 to 18 inches long. Types of anchors include U-shaped wire staples, metal geotexile stake pins, and triangular wooden stakes.
INSTALLATION ON SLOPES:		
☐	PC 4.8	Begin at the top of the slope and anchor the blanket in the 6 inches deep by 6 inches wide trench. Backfill trench and tamp earth firmly.
☐	PC 4.9	Unroll blanket down slope in the direction of water flow.
☐	PC 4.10	Overlap the edges of adjacent parallel rolls 2 to 3 inches and staple every 3 feet.
☐	PC 4.11	When blankets must be spliced, place blankets end over end (shingle style) with 6-inch overlap. Staple through overlapped area, approximately 12 inches apart.
☐	PC 4.12	Lay blankets loosely and maintain direct contact with the soil. Do no stretch the fabric.
INSTALLATION IN CHANNELS:		
☐	PC 4.13	A schematic for typical installation of blankets or mats in channels is provided, however, always consult the manufacturer's recommendations for installation.
☐	PC 4.14	If manufacturer's recommendation for installation involves soil filling, spread and lightly rake 0.25 to 0.50 inches of fine topsoil into the mat to completely fill mat thickness.
PLASTIC SHEETING:		
☐	PC 4.15	Plastic sheeting shall have a minimum thickness of 6 mils and shall be firmly held in place with sandbags or other weights no more than 10 feet apart. Seems shall overlap 12 to 24 inches and be taped or weighted down their entire length.
MAINTENANCE AND INSPECTION:		
☐	PC 4.16	All blankets and mats shall be inspected after installation and significant rainstorms and repaired/replaced if any failures or washouts occur.

Figure 1. Installation of Geotextiles



Detail "A"

Not to Scale

Notes:

1. Begin at the top of the slope and anchor the blanket in a 6 in. deep by 6 in. wide trench. Backfill trench and tamp earth firmly.
2. Unroll blanket down slope in the direction of water flow.
3. Overlap the edges of adjacent parallel rolls 2 to 3 in. and staple every 3 ft.
4. When blankets should be spliced, place blankets end over end (shingle style) with 6 in. overlap. Staple through overlapped area, approximately 12 in. apart.
5. Lay blankets loosely and maintain direct contact with the soil. Do not stretch.
6. Staple blankets sufficiently to anchor blanket and maintain contact with the soil. Staples should be placed down the center and staggered with the staples placed along the edges.
7. Steep slopes, 1:1 (H:V) to 2:1 (H:V), require a minimum of 2 staples/yd^2. Moderate slopes, 2:1 (H:V) to 3:1 (H:V), require a minimum of 1½ staples/yd^2.
8. Install per manufacturer's recommendations.
9. For Limitations, Geotextiles and Plastic Covers Specifications, Types of Erosio: Blankets/Mats, and Site Preparations see EC-7.

Typical Slope Soil Stabilization

Source: City and County of Honolulu BMP Manual, November 2011.

Permanent Best Management Practices
PC5: Vegetated Buffer Strips and Channels

Description

Vegetative buffer strips and channels, also referred to as biofilters, can be used to reduce the discharge of pollutants to the MS4 or receiving water. The vegetated surfaces are used to protect soils from erosion and to slow the velocity of runoff to allow the removal of sediment through filtering and settling. A vegetated buffer strip is a strip of land parallel to and adjacent to the edge of the contributing surface. It can be created with either new vegetation as part of a development project or a strip of existing vegetation that is left undisturbed during adjacent development (see BMP Preservation of Existing Vegetation).

Potential Pollutant Source Controlled

The primary pollutants managed by this BMP are sediment and debris; however, vegetation may also filter a variety of other potential pollutants, such as nutrients, metals, bacteria, oil & grease, organic compounds, etc.

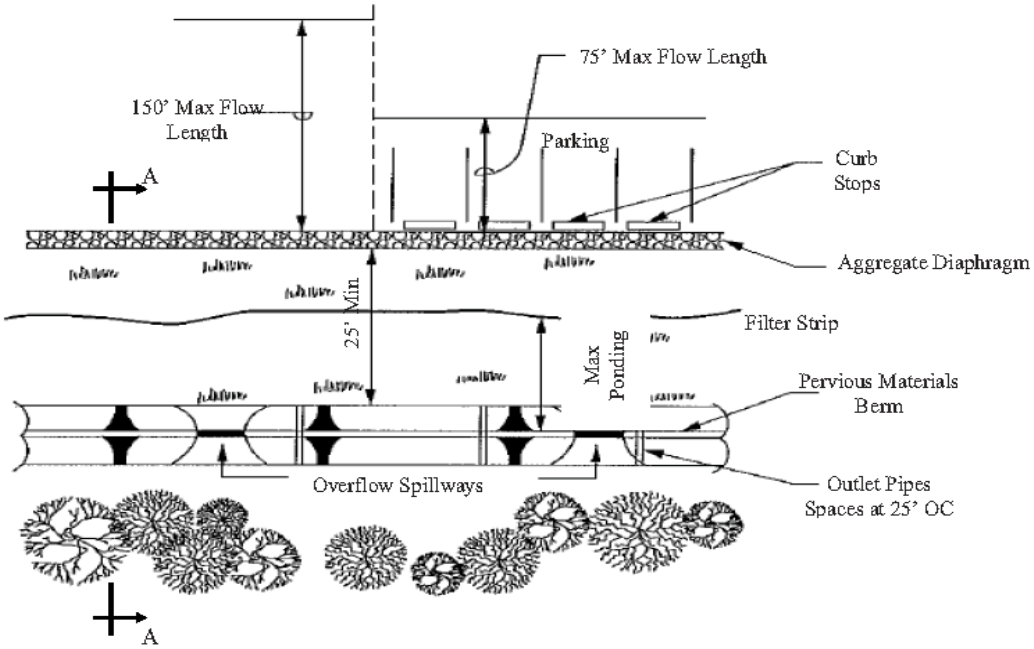
Limitations

- Site conditions, including land availability, may limit the use and design of vegetated buffer strips and channels.
- Performance is dependent upon depth of flow and condition of the vegetation.
- Irrigation may be required to maintain the vegetation during dry periods.
- Maintenance requirements can be high to maintain the design condition of the vegetation.
- Vegetated buffer strips are most economical when there is existing vegetation that can be retained to serve as the buffer strip or when a landscaped area to serve as a buffer strip is incorporated into the site design; otherwise, the site design will need to specifically provide buffer strip areas and vegetation will need to be established.
- Vegetated channels require a larger area than lined channels and this area must be provided in the overall site design.
- Vegetated channels require gradual slopes to limit flow velocities. High flow velocities topple the grass and result in flow over the grass rather than through it.

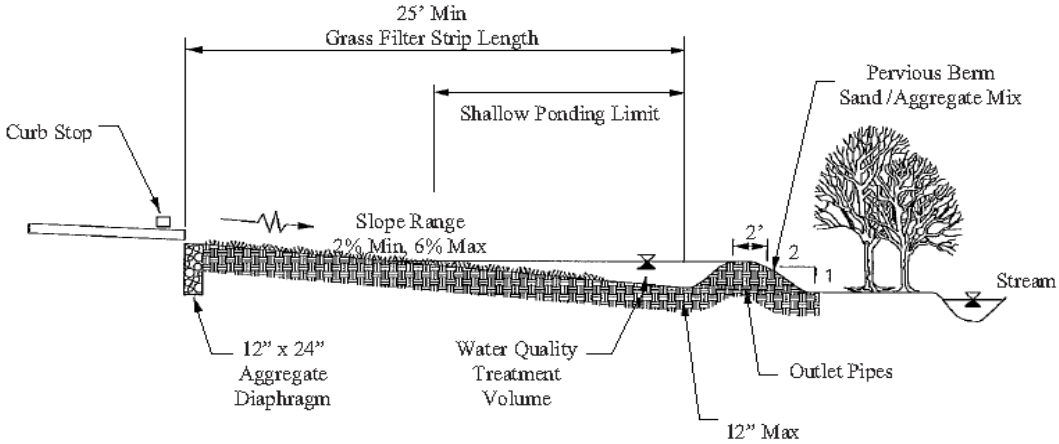
Practice (*Refer to Figure 2)		
☐	PC 5.1	All weeds and debris shall be removed before cultivation of the area and disposed properly.
☐	PC 5.2	Strip and stockpile good topsoil during construction for use in surface preparation prior to planting.
☐	PC 5.3	Plant as soon as possible after the area has been graded.
☐	PC 5.4	After cultivation and installation of irrigation systems (if used) are completed, areas to be planted shall be fine graded and rolled. Topsoil may be needed in areas where soil textures are inadequate.
☐	PC 5.5	Water or irrigate the vegetation as needed to supplement rainfall until established.
☐	PC 5.6	Fertilize in accordance with label instructions and the needs of the soil as indicated by tests.
☐	PC 5.7	Avoid using the buffer strip or vegetated channel for vehicular traffic, as it will damage the vegetation and reduce its effectiveness.
☐	PC 5.8	Application of fertilizers and pesticides, or other soil amendments or chemicals, shall comply with all applicable regulations and label instructions.
☐	PC 5.9	Select a seed mixture appropriate to the site conditions, remembering that dense grasses are the most effective in slowing flow velocities and erosion as well as removing pollutants such as sediment.
☐	PC 5.10	Use planting equipment and methods that provide uniform distribution and placement of seed.
☐	PC 5.11	Sod shall be protected with tarps or other protective covers during delivery and shall not be allowed to dry out between harvesting and placement.

☐	PC 5.12	If irregular or uneven areas appear before or during the plant establishment period, such areas shall be restored to a smooth and even appearance.
☐	PC 5.13	Inspect plantings weekly and after significant storm events, until turf is established, and routinely thereafter. Repair eroded or damaged areas as needed to maintain effectiveness as a buffer strip.
☐	PC 5.14	Maintenance shall consist of mowing, weeding, and ensuring that the irrigation system (if used) is operating properly to sustain growth.

Figure 2. Vegetated Buffer Strips and Channels



Detail "A"
Plan View, Not to Scale



Section A-A
Not to Scale

Notes:
1. For Implementation see City and County of Honolulu Storm Water Construction BMP Details SE-14 (Vegetated Buffer Strips and Channels).
2. If existing vegetation will be used as a buffer strip, EC-2 (Preservation of Existing Vegetation).

Typical Vegetated Buffer Strip

Source: Prince George's County, Low-Impact Development Design Strategies: An Integrated Environmental Design Approach, 1999

Source: City and County of Honolulu BMP Manual, November 2011.

Permanent Best Management Practices
PC6: Earth Dikes, Drainage Swales, and Lined Ditches

Description
Earth dikes, drainage swales, and lined ditches are structures that intercept, divert, and convey surface runoff. The primary functions of such structures are to prevent erosion and to reduce pollutant loading conveyed to receiving waters. Typical drainage swales and earth dike sections are attached.

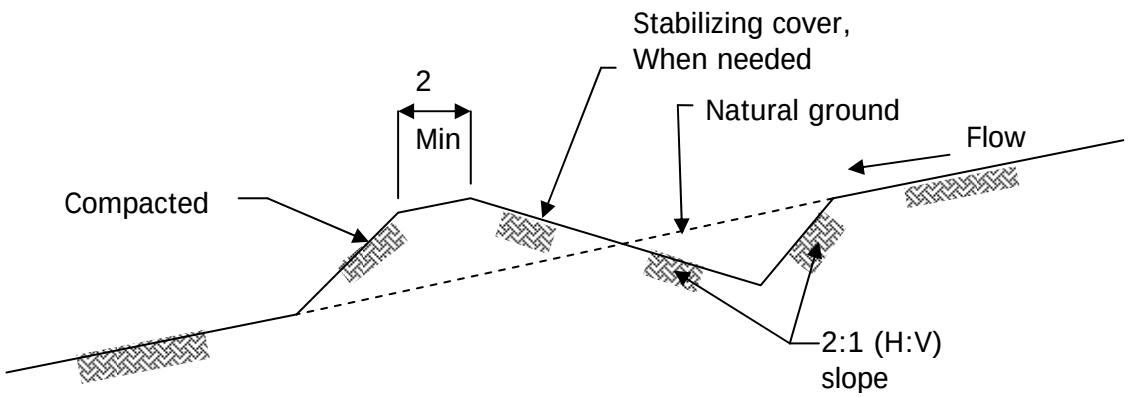
Potential Pollutant Source Controlled
When vegetated, the primary pollutants managed by this BMP are sediment and debris; however, vegetation may also filter a variety of other potential pollutants, such as nutrients, metals, bacteria, oil & grease, organic compounds, etc.

Limitations
Earth dikes, drainage swales and lined ditches must be correctly sized and located. Excessively steep, unlined ditches and swales are subject to erosion and gully formation. Unstabilized tributary areas will reduce the effectiveness of these measures, which can cause water to pond in tributary areas will reduce the effectiveness of these measures, which can cause water to pond in active traffic lanes, material storage areas, etc., if not properly sized. Altering existing waterways or clearing existing vegetation may require permits from the Hawaii Department of Health or the U.S. Army Corps of Engineers.

Practice		
☐	PC 6.1	Select the design flow and safety factor based on evaluation of the risks associated with erosion and over topping, flow backups, or wash out of the structure.
☐	PC 6.2	Examine the site for run-on from off-site sources.
☐	PC 6.3	Select a flow velocity limit based on site-specific soil types and drainage flow patterns.
☐	PC 6.4	Establish a maximum flow velocity for using earth dikes and swales, above which a lined ditch must be used.
☐	PC 6.5	Design an emergency overflow section or bypass area for larger storms that exceed the design storm.
☐	PC 6.6	Install and utilize permanent dikes, swales, and ditches early in the construction process.
☐	PC 6.7	Conveyances must be lined when velocities exceed allowable limits for the soil type. Consider use of riprap, engineering fabric, vegetation, or concrete.
☐	PC 6.8	If sediment-laden water is expected in those conveyances, discharge flows from the conveyance into a sediment-trapping device.
☐	PC 6.9	Temporary conveyances are to be completely removed as soon as the surrounding drainage area has been stabilized, or at the completion of construction.
☐	PC 6.10	Inspect permanent conveyances at least once every two years.

*Example Drainage Swale and Earth Dike attached.

Figure 3. Typical Drainage Swale Design



TYPICAL DRAINAGE SWALE

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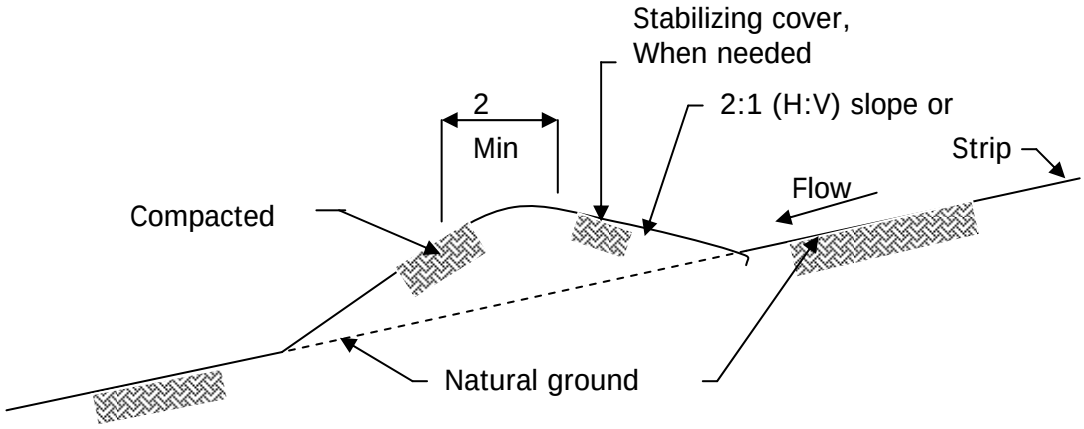


TYPICAL EARTH DIKE

NOT TO SCALE

Source: California Stormwater BMP Handbook. January 2003.

Permanent Best Management Practices
PC7: Slope Drains and Subsurface Drains

Description
A slope or subsurface drain is a pipe used to intercept and direct surface runoff or ground water into a stabilized watercourse, trapping device or other stabilized area. The primary function of a slope drain is to convey runoff down cut or fill slopes. A typical slope drain schematic is attached. The primary function of subsurface drains is to drain excessive soil saturation in sloping areas.

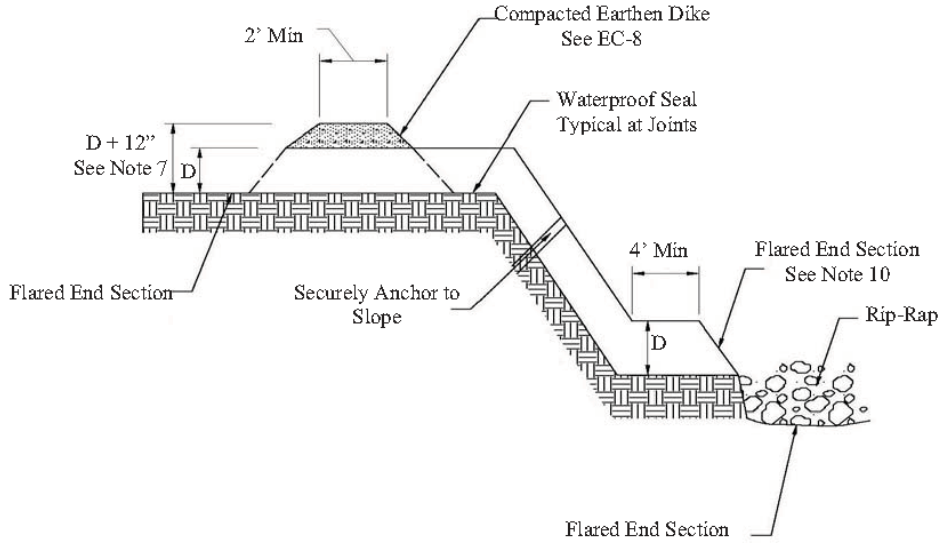
Potential Pollutant Source Controlled
This BMP assists in preventing erosion, which will control potential pollution from sediment.

Limitations
- Severe erosion may result when slope drains fail by over topping or pipe separation.
- Subsurface drains may remove fine soils, which can result in slope failure.

Practice		
DESIGNING SLOPE DRAINS:		
☐	PC 7.1	Limit drainage area per pipe to 10 acres. For larger areas, use a lined channel or a series of pipes.
☐	PC 7.2	Use interceptor dikes to direct surface runoff into a slope drain.
☐	PC 7.3	Use a standard flared end section or headwall at the entrance to pipe slope drains larger than 12 inches to improve inlet hydraulics.
☐	PC 7.4	Place drainpipes on or bury them underneath the sloped surface.
☐	PC 7.5	Direct flows to a detention basin if the slope drain has the potential to convey sediment-laden water.
INSTALLING SLOPE DRAINS:		
☐	PC 7.6	Install perpendicular to slope contours.
☐	PC 7.7	Maximum slope shall be 2:1 (H:V). If a steeper slope is required, use extra durable outlet protection.
☐	PC 7.8	Protect area around inlet with lining such as vegetation, filter cloth, etc.
☐	PC 7.9	Protect outlets with riprap or some other method of energy dissipation. Where high exit velocities are expected, reinforce riprap with concrete or use reinforced concrete device.
☐	PC 7.10	Compact soil around and under entrance, outlet, and along length of pipe.
☐	PC 7.11	Securely anchor and stabilize pipe and appurtenances into soil.
DESIGNING SUBSURFACE DRAINS:		
☐	PC 7.12	Review relative size of soil and slot/perforation size in the pipe to prevent sediment from entering pipe.
☐	PC 7.13	Install relief drains for groundwater table lowering parallel to the slope, and drain to the side of the slope. Use a gridiron, herringbone, or random pattern.
☐	PC 7.14	Install interceptor drains to prevent excessive soil saturation perpendicular to the slope and divert the discharge to the side of the slope.
☐	PC 7.15	Inspect slope and subsurface drains annually during the rainy season. Follow routine inspection procedures for inlet thereafter.

*Example Slope Drain attached.

Figure 4. Slope Drain Design



Section "A"

Notes:

1. Install slope drains perpendicular to slope contours.
2. Slope drains can be placed on or buried underneath the slope surface.
3. Compact soil around and under entrance, outlet, and along length of pipe.
4. Securely anchor and stabilize pipe and appurtenances into soil.
5. Check to ensure that pipe connections are watertight.
6. Protect area around inlet with filter cloth.
7. Top of interceptor dikes should be 12 in. higher than the top of the slope drain.
8. Maximum slope generally limited to 2:1 (H:V).
9. Direct surface runoff to slope drains with interceptor dikes. See BMP EC-00, Earth Dikes and Drainage Swales.
10. Protect outlet of slope drains using a flared end section when outlet discharges to a flexible energy dissipation device. The flared section should slope towards the pipe inlet.
11. The pipe size may be computed using the Rational Method or alternate methods accepted by the City and County of Honolulu.

As a guide, temporary pipe slope drains should not be sized smaller than shown in the following table:

Minimum Pipe Diameter, D (Inches)	Maximum Drainage Area (Acres)
12	1.0
18	3.0
21	5.0
24	7.0
30	10.0

12. Recommended materials include both metal and plastic pipe, either corrugated or smooth wall. Concrete pipe can also be used.

Typical Slope Drain

Source: City and County of Honolulu BMP Manual, November 2011.

Permanent Best Management Practices
PC8: Top and Toe of Slope Diversion Ditches/Berms

Description
Top and toe of slope diversion ditches/berms are devices used to intercept and direct surface runoff to a slope drain, stabilized watercourse, or stabilized area. The primary function of top and toe of slope diversion ditches/berms is to:

- Minimize sheet flow over slope surfaces.
- Reduce sedimentation by conveying collected runoff to a protected drainage system.

Potential Pollutant Source Controlled
This BMP assists in preventing erosion, which will control potential pollution from sediment.

Limitations
Ditches/berms are not sediment trapping devices. If it is anticipated that sediment-laden water will be discharged to the diversion structure, a detention basin or other means to settle and collect soil particles needs to be provided.

Practice		
☐	PC 8.1	Select design flow and safety factors based on evaluation of risks associated with erosion and overtopping, flow backups, or washout of the structure.
☐	PC 8.2	Line or stabilize ditches where high flow velocities will occur.
☐	PC 8.3	At top of slope, direct flow to slope drains.
☐	PC 8.4	When installing diversion ditches and berms protect outlets from erosion.
☐	PC 8.5	Use planned permanent ditches/berms early in the construction phase when practicable.
☐	PC 8.6	Inspect permanent measures prior to the rainy season, after rainfall events, and regularly (approximately once per month) during the rainy season.
☐	PC 8.7	Inspect ditches/berms for washouts. Replace lost riprap, damaged linings or soil stabilizers as needed.
☐	PC 8.8	Inspect structures and their inlets and outlets for accumulation of debris and sediment. Remove debris and sediment as needed.

Permanent Best Management Practices
PC9: Outlet Protection / Velocity Dissipation Devices

Description
Outlet protection/velocity dissipation devices are physical mechanisms placed at the outlets of pipes and channels. The primary function of such devices is to reduce the velocity and/or energy of existing water, preventing scour and minimizing the potential for downstream erosion. A typical outlet protection design is attached.

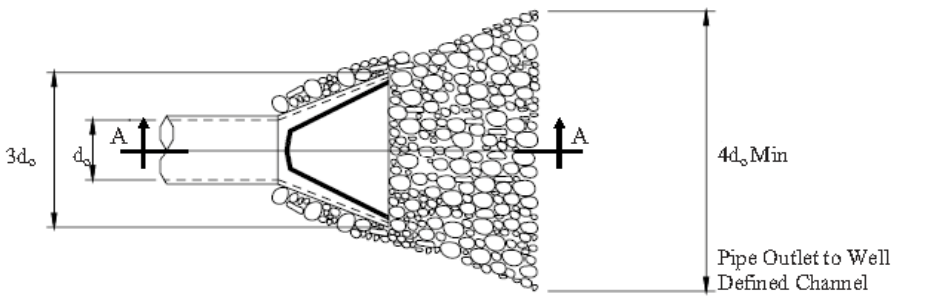
Potential Pollutant Source Controlled
This BMP assists in preventing erosion, which will control potential pollution from sediment.

Limitations
- Ungrouted riprap may have stones washed away by flows that exceed the design flow.
- Grouted riprap may break up from hydrostatic pressure unless adequate subsurface drainage is provided.

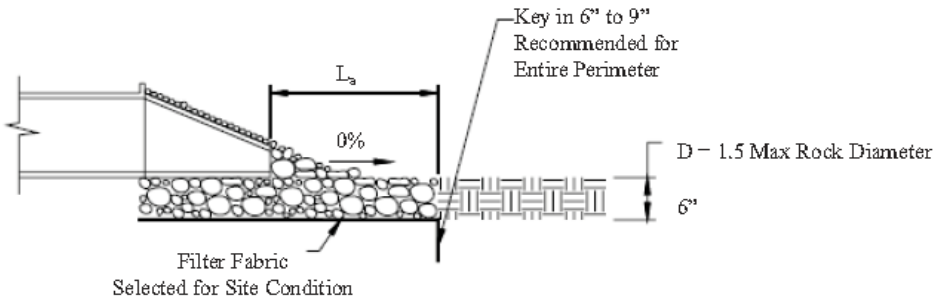
Practice		
☐	PC 9.1	Apron length shall be based on outlet flow rate and tail-water level.
☐	PC 9.2	Align apron with receiving stream and keep the apron straight throughout its length. If a curve is needed to fit site conditions, place it in the upper section of the apron.
☐	PC 9.3	If the size of apron riprap is 12 inches or longer, protect the underlying filter fabric with 4 inches minimum of gravel blanket.
☐	PC 9.4	Provide additional protection where flow re-concentration and high flow velocities leaving the apron can occur, such as at the top of cut slopes or on slopes steeper than 10 percent.
☐	PC 9.5	Establish a routine inspection schedule for permanent measures so that all structures are inspected at least once every three years.

*Example Outlet Protection attached.

Figure 5. Outlet Protection Design



Plan"A"



Section A-A

Notes:

1. The apron length and rock size gradation are determined using the table above.
2. Install riprap, grouted riprap, or concrete apron at selected outlet. Riprap aprons are best suited for temporary use during construction. Grouted or wired tied rock riprap can minimize maintenance requirements.
3. Carefully place riprap to avoid damaging the filter fabric.
   a. Stone 4 in. to 6 in. may be carefully dumped onto filter fabric from a height not to exceed 12 in.
   b. Stone 8 in. to 12 in. should be hand placed onto filter fabric, or the filter fabric may be covered with 4 in. of gravel and the 8 in. to 12 in. rock may be dumped from a height not to exceed 16 in.
   c. Stone greater than 12 in. should only be dumped onto filter fabric protected with a layer of gravel with a thickness equal to one half the D50 rock size, and the dump height limited to twice the depth of the gravel protection layer thickness.
4. Outlets on slopes steeper than 10 percent should have additional protection.
5. Design should comply with city and state regulations.

Pipe Diameter, do (inches)	Discharge (ft^3/s)	Apron Length, La (ft)	Rip Rap D50 Diameter Min (inches)
12	5	10	4
	10	13	6
18	10	10	6
	20	16	8
	30	23	12
	40	26	16
24	30	16	8
	40	26	8
	50	26	12
	60	30	16

For larger or higher flows consult a Licensed Civil Engineer

Source: USDA- SCS

Source: City and County of Honolulu BMP Manual, November 2011.

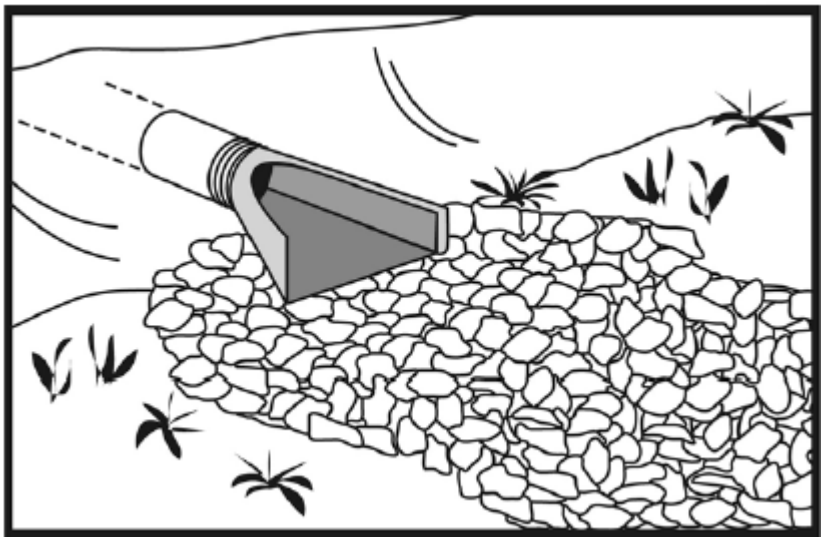
Permanent Best Management Practices
PC10: Flared Culvert End Sections

Description
Flared culvert end sections are physical devices at the inlets and outlets of pipes and channels. The primary function of flared culvert end sections is to help prevent scour and minimize erosion at inlets and outlets. Such end sections can also improve the hydraulic operation and retain the embankment near pipe conveyances. A general design concept for a flared end section is attached.

Potential Pollutant Source Controlled
This BMP assists in preventing erosion, which will control potential pollution from sediment.

Limitations
Flared end sections primarily provide hydraulic efficiency within a drainage system. They also provide limited erosion control benefits.

Practice		
☐	PC 10.1	Construct at zero grade when possible.
☐	PC 10.2	Use in conjunction with other outlet protection.
☐	PC 10.3	At inlets, protect the transition into a flared end section to prevent scouring.
☐	PC 10.4	Inspect flared end sections before the rainy season.



Source: Department of Transportation, Highways Division. Storm Water Permanent BMP Manual. March 2007.

Permanent Best Management Practices
PC11: Slope Roughening / Terracing / Rounding

Description
Roughening, terracing, and rounding are techniques used for creating down slope unevenness on bare soil. This is done by constructing furrows or intermediate benches running across a slope or by use of construction equipment to track the soil surface. The primary function of surface roughening or terracing is to reduce erosion potential by decreasing runoff velocities, reducing the length of sheet flow, trapping sediment, and increasing infiltration of water into the soil.

Potential Pollutant Source Controlled
This BMP assists in preventing erosion, which will control potential pollution from sediment.

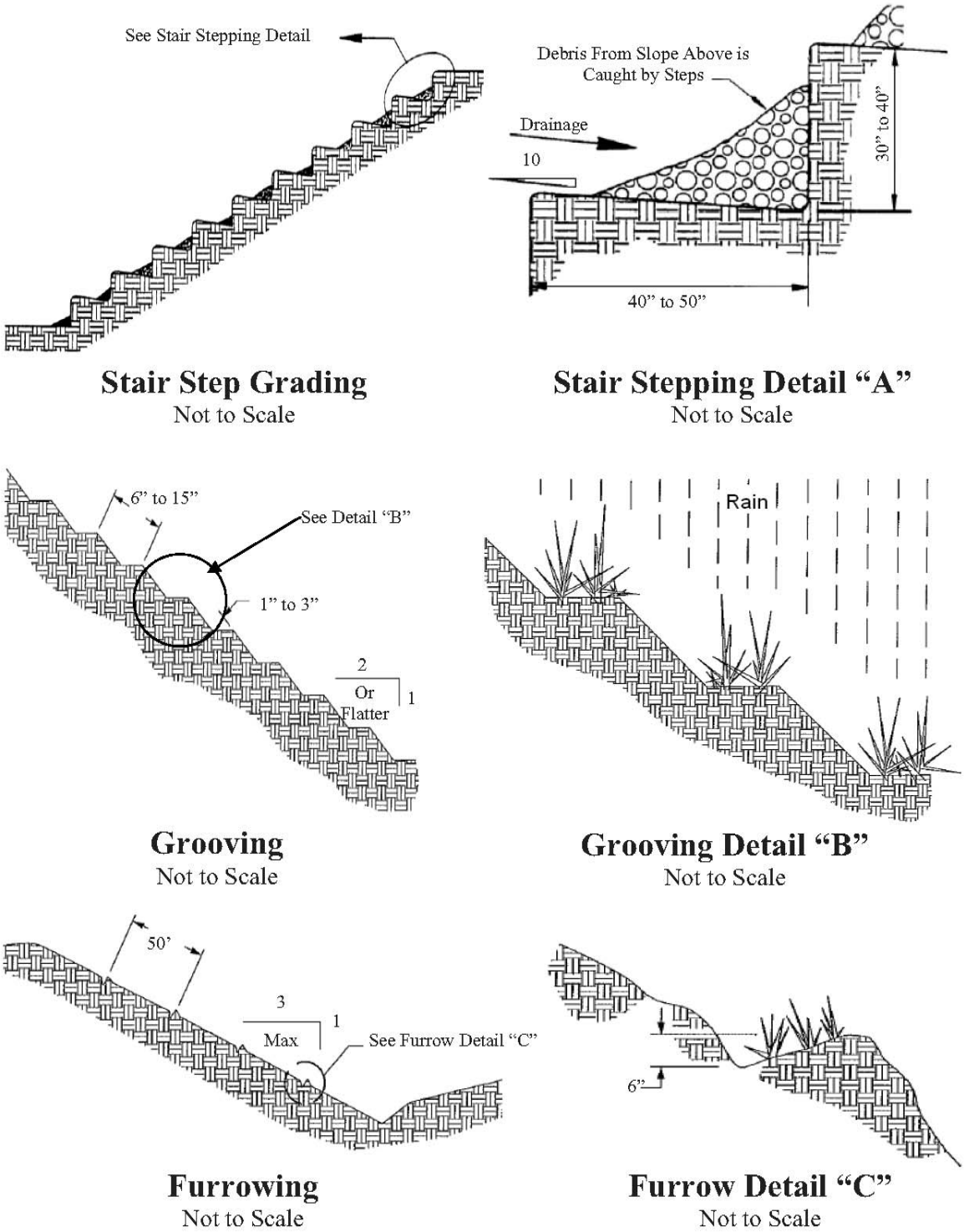
Limitations
- Roughening may increase grading costs and lead to sloughing in certain soil types.
- Stair-step grading may not be practical for sandy, steep, or shallow soils.
- Roughening alone as a temporary erosion control or surface preparation measure is of limited effectiveness in intense rainfall events. If roughening effects are washed away in a heavy storm, the surface will have to be re-roughened and new seed and mulch applied.

Practice		
CUT SLOPE ROUGHENING:		
☐	PC 11.1	Use stair-step grading or furrows (groove cuts) on slopes that are steeper than 3:1 (H:V) and on erodible material that is soft enough to be ripped by a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
☐	PC 11.2	Make the vertical cut distance less than the horizontal distance, and slightly slope the horizontal position of the "step" in towards the slope.
☐	PC 11.3	Do not make individual vertical cuts more than 24 inches high in soft materials or more than 36 inches high in rocky materials.
☐	PC 11.4	Groove the slope using machinery to create a series of ridges and depressions that run across the slope and on the contour.
FILL SLOPE ROUGHENING:		
☐	PC 11.5	Place fill slopes with gradient steeper than 3:1 (H:V) in lifts not exceeding 8 inches, and assure each lift is properly compacted. The face of the slope shall consist of loose, uncompacted fill 4 to 6 inches deep. Do not blade or scrape the final slope face.
☐	PC 11.6	Use grooving or tracking to roughen the face of the slopes, as necessary.
CUTS, FILLS, AND GRADED AREAS:		
☐	PC 11.7	Slopes that will be maintained by mowing shall be no steeper than 3:1 (H:V).
☐	PC 11.8	To roughen these areas, create shallow grooves by normal tilling, disking, harrowing, or use a cultivator-seeder. Make the final pass of any such tillage on the contour.
☐	PC 11.9	Make grooves formed by such implements close together, less than 10 inches apart and not less than 1 inch deep. Excessive roughness is undesirable where mowing is planned.
ROUGHENING WITH TRACKED MACHINERY:		
☐	PC11.10	Limit roughening with tracked machinery to soils with a sandy texture to avoid undue compaction of the soil surface.
☐	PC11.11	Operate tracked machinery up and down the slope to leave horizontal depressions in the soil.
TERRACING:		
☐	PC11.12	Terraces or benches are to be considered in design of slopes 4:1 (H:V) when slope heights exceed 30 feet. For highly erosive soils, and steeper slopes, slope heights as low as 15 feet are considered.

☐	PC11.13	Runoff from terraces and benches are to be directed to lined diversion ditches, installed where the terrace meets the slope.
☐	PC11.14	All slopes shall be rounded and then seeded and mulched to obtain seed germination and growth.

*Example Slope Terracing attached.

Figure 6. Slope Terracing Designs



Source: City and County of Honolulu BMP Manual, November 2011.

Permanent Best Management Practices
PC12: Level Spreader

Description
A level spreader is an outlet for dikes and diversions that disperses the runoff discharged from the slope. Its primary function is to help reduce erosion by dispersing small volumes of concentrated runoff as sheet flow. A level spreader can be the top of a channel, an earthen berm, or a rigid weir-like structure that distributes flow fairly evenly across its length at non-erosive velocities onto stabilized areas.

Potential Pollutant Source Controlled
This BMP assists in preventing erosion, which will control potential pollution from sediment.

Limitations
The maximum flow into a level spreader shall not exceed 30 cubic feet per second. The level spreader lip must have a zero slope for proper operation, allowing the discharged water to flow evenly onto the stabilized area. A level spreader is not a sediment trapping or filtering device. Water flowing into the level spreader should be free of sediment.

Practice		
☐	PC 12.1	Construct a level spreader on undisturbed soil and not on fill material.
☐	PC 12.2	Runoff water containing high sediment loads must be treated in a sediment-trapping device before being released to a level spreader.
☐	PC 12.3	Use a rigid outlet lip design for high discharge flow conditions.
☐	PC 12.4	The outlet area below the level spreader must be uniform and well vegetated having a slope of 10% or less.
☐	PC 12.5	Do not allow discharge flow to re-concentrate below the level spreader outlet.
☐	PC 12.6	Vehicles and heavy equipment are not to be operated in the level spreader, because they can create surface indentations that concentrate flow.
☐	PC 12.7	Inspect for debris and sediment accumulation in the level spreader channel. Remove accumulated debris and sediment within 30 days of inspection.
☐	PC 12.8	Inspect level spreaders prior to the rainy season and after rainfall events exceeding their design storm intensity (25-year recurrence interval, 1-hour duration, unless otherwise directed).

Permanent Best Management Practices
PC13: Infiltration Trench

Description

The infiltration trench provides recharge and water quality volume in one location. Infiltrated storm water shall be filtered through soils prior to entering groundwater. Storm water can also be filtered for pollutants by other suitable media that is accompanied by a certification from a licensed civil engineer, stating that the filter/device will remove 80 percent of total suspended solids from the design flow rate. Infiltration will only be used where soil conditions and slope stability are suitable.

Potential Pollutant Treatment

This BMP provides a high level of treatment for all targeted pollutants (e.g. nutrients, sediment, trash, bacteria, pesticides, oil & grease, metals, and organic compounds).

Limitations

- Underlying soils need to have specific infiltration rates, which may be tested with geotechnical borings.
- Soils shall have a clay content of less than 20% and a silt/clay content of less than 40%.
- Infiltration cannot be located on slopes greater than 15% or within fill soils.

Practice		
☐	PC 13.1	Calculate flow to determine capacity: **WQFR = C x 0.4" x A** • WQFR = water quality flow rate in cubic feet per second • C = runoff coefficient (C =0.8 for pervious surface, C= 0.9 for impervious surface). • A = area of the site in acres • 0.4" = hourly rainfall intensity
☐	PC 13.2	The bottom of the trench will be separated by at least 4" vertically for the seasonally high water table or bedrock layer. The trench will be located at least 100 feet away from any water well.
☐	PC 13.3	The trench will have a maximum contributing area of five acres.
☐	PC 13.4	All trenches will be designed to fully de-water the entire water quality volume within 48 hours after the storm event.
☐	PC 13.5	Provide adequate outfalls for the overflow associated with the ten-year design storm event.
☐	PC 13.6	Since the trench will be located "off-line" from the main conveyance system, a flow splitter will be required to divert the water quality volume into the filter.
☐	PC 13.7	Trench construction specifications should state the earliest point in progress when storm drainage may be directed to the trench.
☐	PC 13.8	Final excavation to the final grade should be done after all disturbed areas in the watershed area are stabilized or protected.
☐	PC 13.9	After the completion of final grading, the trench should be well aerated and have a highly porous surface texture.
☐	PC13.10	Trenches may be lined with a 6 to 12 inch layer of filter material, such as coarse sand to help prevent the build-up of impervious deposits. The filter layer can be replaced or cleaned when clogged.
☐	PC13.11	Establish dense vegetation on trench side slopes and floor to prevent erosion and maintain high infiltration rates.
☐	PC13.12	Long-term techniques for infiltration protection are required (2 per trench): • Grass channel • Grass filter strip (minimum 20 feet and only if sheet flow is established and maintained) • Bottom sand layer • Upper sand layer (6" minimum) with filter fabric at sand/gravel interface • Washed bank run gravel used as aggregate

Permanent Post-Construction Best Management Practices
PC14: Retention Basin

Description

A retention basin is a surface depression designed to capture the runoff volume from the water quality design storm for disposal through evaporation and percolation. The primary functions of retention basins are to remove pollutants from storm water runoff where soil conditions are suitable, and to recharge or replenish ground water. In addition, retention basins can significantly reduce total annual surface runoff volume, which can reduce stream bank erosion and other adverse impacts to stream habitats from storm water runoff.

Potential Pollutant Treatment

This BMP provides treatment by reducing the volume and velocity of the storm water runoff and may also remove other pollutants that may be present in the runoff such as trash, sediment, metals, and oil & grease.

Limitations

- Retention basins can be effectively used only where the soil porosity and evapotranspiration capacity are adequate to dispose of the required quantity of storm water within a reasonable period of time, typically considered to be not more than 5 days. This allows the basin's capacity to be reestablished and reduces the potential for unsanitary conditions, such as mosquito breeding, associated with stagnant water.
- The wet-weather table must be at least 3 feet below the bottom of the retention basin.
- Very porous soils provide low removal of dissolved pollutants, which an increase the risk of ground water contamination.
- Retention basins may not be suitable near drinking water wells, foundations, septic tanks, drain fields, fill sites or steep, unstable slopes.
- Retention basins are not used where there is significant potential for hazardous chemical spills.
- Retention basins usually fail if they receive high sediment loads. Therefore, retention basins are not to be used until upstream drainage area is stabilized.

Practice		
☐	PC 14.1	Calculate flow to determine capacity: **WQFR = C x 0.4" x A** • WQFR = water quality flow rate in cubic feet per second • C = runoff coefficient (C =0.8 for pervious surface, C= 0.9 for impervious surface). • A = area of the site in acres • 0.4" = hourly rainfall intensity
☐	PC 14.2	Special precautions must be applied to the project scheduling, construction techniques, and the equipment used to protect the natural infiltration rate.
☐	PC 14.3	Lightweight equipment and construction procedures that minimize compaction shall be used. The basin area shall be flagged off while heavy equipment is in the area.
☐	PC 14.4	Storm water shall be not allowed to enter the retention basin until all construction is completed and the contributing drainage area to the basin is adequately stabilized. If this prohibition is not feasible in particular situations, do not excavate the facility to the final grade until the contributing drainage area has been stabilized.
☐	PC 14.5	Retention basins are to be inspected annually and following significant storm events.
☐	PC 14.6	Debris and sediment accumulations are to be removed from the retention basin whenever these materials prevent proper functioning of the basin. Generally, this occurs when the sediment layer exceeds 12 inches.
☐	PC 14.7	Retention basin floors shall be tilled as needed to restore the infiltration capacity and to control weed growth on the basin floor. Tilling shall be accomplished using rotary tillers or disc harrows.

Permanent Best Management Practices
PC15: Green Roofs

Description

A green roof, or rooftop garden, is a vegetative layer grown on top of an elevated impervious surface. Green roofs provide shade and reduce the heat within the structure through evapotranspiration, which reduces the temperatures of the roof surface and the surrounding air. In addition to mitigating urban heat islands, green roofs provide enhanced storm water management and water quality treatment. They can reduce and slow storm water runoff from impervious areas. The plants and growing medium of a green roof, in the same manner as other natural surfaces and vegetation, absorb water that would otherwise become runoff. Green roofs can be installed on a wide range of buildings, from industrial facilities to private residences. They can be as simple as a 2-inch covering of hardy groundcover generally termed an "extensive" system, or as complex as a fully accessible park complete with trees, called an "intensive" system.

Potential Pollutant Treatment

This BMP provides treatment by reducing the volume and velocity of the storm water runoff and provides a high level of pollutant removal for sediment, trash, and oil & grease.

Limitations

The amount of rainfall retained by a green roof will depend primarily on the depth of the growing medium and may also be affected by the roof slope.

Practice		
☐	PC 15.1	Select succulent, hardy varieties of plants that do not require shade as well as other vegetation general suitable for the environment in Hawaii.
☐	PC 15.2	Ensure that roof structure can support the added weight of both plants and growing media.
☐	PC 15.3	Choose roofs with a slope between 0 to 40 degrees.
☐	PC 15.4	Immediately after planting, inspect green roof frequently to ensure that the vegetation is thriving.
☐	PC 15.5	After the first season, inspect and fertilize green roofs once per year and during draught conditions.
☐	PC 15.6	Intensive green roofs may require the installation of an irrigation system.

Permanent Best Management Practices
PC16: Alternative Wetlands

Description

The Federal Aviation Administration (FAA) requires that wildlife, specifically birds, be limited within the airport due to the safety threat they pose to the aircraft. Therefore, it is not recommended that large wetlands be developed within the airport limits, since they will likely draw local bird populations. However, alternative wetlands can be considered.

Floating Wetlands are constructed of vegetation grown on a raft. The raft is placed in a polluted body of water such as a canal and the plants draw pollutants out of the water. Depending on the type of plant, the pollutant will either be stored in the plant or metabolized.

Modular Wetlands are small wetlands that can be created adjacent to storm drains. These wetlands are usually accompanied by a 4-Stage Treatment Train. They can be used to treat the storm water in the MS4 as well as to reduce the flow rate.

Potential Pollutant Treatment

This BMP provides a high level of treatment for all targeted pollutants (e.g. nutrients, sediment, trash, bacteria, pesticides, oil & grease, metals, and organic compounds).

Limitations

Prior approval from DOTA will be required to connect a new drain with the MS4.

Practice		
☐	PC 16.1	Determine the type of alternative wetland needed and the size of the area to be treated.
☐	PC 16.2	Pick hardy plants common to Hawaii in order to limit the watering and landscaping requirements.
Floating Wetlands		
☐	PC 16.3	Construct a raft by either pinning together potted plants or using coir or other compatible substance for the base.
☐	PC 16.4	Pre-plant the vegetation and anchor in the water (culvert or stream).
☐	PC 16.5	Inspect the rafts to ensure that the vegetation remains viable and the raft is intact.
☐	PC 16.6	If using the raft to treat the water, non-viable vegetation may have to be treated as hazardous waste.
Modular Wetlands		
☐	PC 16.7	Design the storm drain so that the water will be directed through the plant bed before entering the MS4.
☐	PC 16.8	Provide a bypass valve for heavy storm water flows.
☐	PC 16.9	Consider included a trap to collect large debris items to prevent the vegetation bed from clogging.
☐	PC16.10	Inspect the drain and remove the filter if applicable, ensure the vegetation is viable, and that water is flowing through the drain.
Other Wetlands		
☐	PC16.12	Follow the manufacturer's instructions for any other type of alternative wetland.

Permanent Best Management Practices
PC17: Green Parking

Description
Green parking refers to several techniques that applied in the right combination can reduce the total impervious groundcover; thereby reducing the quantity of storm water runoff.

Potential Pollutant Treatment
This BMP provides a high level of treatment for most targeted pollutants with the exception of trash and debris (e.g. nutrients, sediment, bacteria, pesticides, oil & grease, metals, and organic compounds).

Limitations
Green parking may not work in all instances.

Practice		
☐	PC 17.1	Determine the size of the parking lot based on the average parking demand versus the peak demand.
☐	PC 17.2	Minimize the dimensions of parking spaces within the limitations of the local code.
☐	PC 17.3	Use bioretention areas to treat storm water.
☐	PC 17.4	Encourage carpooling.
☐	PC 17.5	Utilize alternative pavers in parking areas.

Permanent Best Management Practices
PC18: Alternative Pavers

Description

Alternative pavers are permeable surfaces that can replace asphalt or concrete and can be used for driveways, parking lots, and walkways. Alternative pavers include gravel, cobbles, wood, mulch, brick, grass pavers, turf blocks, natural stone, pervious concrete, and porous asphalt. This reduces the amount of impervious surface and therefore reduces storm water runoff. Additionally, the pavers can act as a filter for the runoff to remove contaminants. Alternative pavers can be used in conjunction with green parking techniques and bioretention. The following table shows the level of water quality effectiveness achieved by each material and the associated costs.

Material	Water Quality Effectiveness	Installation Cost	Maintenance Cost
Conventional Asphalt/ Concrete	Low	Medium	Low
Brick (in a loose configuration)	Medium	High	Medium
Natural Stone	Medium	High	Medium
Gravel	High	Low	Medium
Wood Mulch	High	Low	Medium
Cobbles	Medium	Low	Medium

Source: Bay Area Stormwater Management Agencies Association (BASMAA). January 1997. *Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection*. BASMAA, San Francisco, CA.

Potential Pollutant Treatment

This BMP provides a high level of treatment for most targeted pollutants with the exception of trash and debris (e.g. nutrients, sediment, bacteria, pesticides, oil & grease, metals, and organic compounds).

Limitations

Alternative pavers are not recommended for high traffic volumes. A discharge pipe from the alternative pavement should be connected to the MS4 with approval from DOTA to allow for bypass during large storm events.

Practice		
☐	PC 18.1	Paving blocks are blocks that are laid in a grid to allow space between the blocks.
☐	PC 18.2	Determine the infiltration rate based on the known storm events and soil type. Soils should have an infiltration rate of 0.5 inches per hour.
☐	PC 18.3	Install a discharge pipe from the alternative pavement area to allow bypass during large storm events.
☐	PC 18.4	Frequent sweeping is important to prevent clogging.
☐	PC 18.5	Landscaping upland of the alternative pavers is important to reduce sediment loads in the runoff.
☐	PC 18.6	Inspect the alternative pavers for weathering including paver breakage and cracking as well as potential pollutants, such as oil leaks and sediment build-up.
☐	PC 18.7	Respond to oil leaks with absorbent materials and/or remove the contaminated sediment.

Permanent Best Management Practices
PC19: Bioretention

Description
Bioretention combines open space with storm water treatment in vegetated areas where runoff is directed through vegetation and soils for filtration. It captures and temporarily stores the water quality volume and passes it through a filter bed of sand, organic matter, soil, or other media. Filtered runoff may be collected and returned to the conveyance system or allowed to partially infiltrate into the soil.

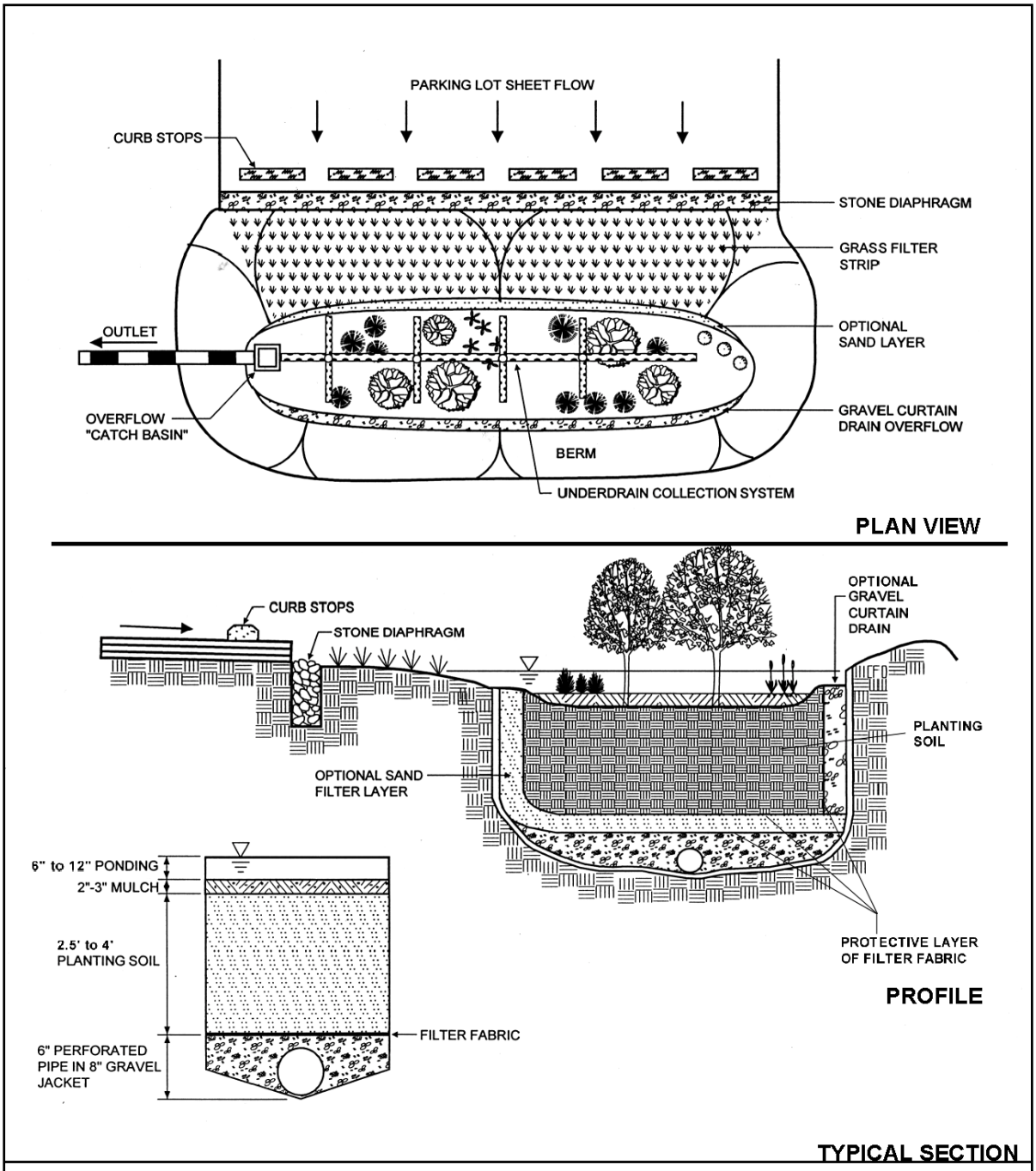
Potential Pollutant Treatment
This BMP provides a high level of treatment for all targeted pollutants (e.g. nutrients, sediment, trash, bacteria, pesticides, oil & grease, metals, and organic compounds).

Limitations
Unless there is adequate infiltration capacity, under drains and overflow drains should be included to collect and discharge filtered runoff to the storm drainage system.

Practice		
☐	PC 19.1	A porosity value "n" (n=Void Volume/Total Volume) of 0.40 should be used in the design of stone reservoirs for infiltration methods.
☐	PC 19.2	Calculate flow to determine capacity: **WQFR = C x 0.4" x A** • WQFR = water quality flow rate in cubic feet per second • C = runoff coefficient (C =0.8 for pervious surface, C= 0.9 for impervious surface). • A = area of the site in acres • 0.4" = hourly rainfall intensity
☐	PC 19.3	Calculate the required filter bed area (Af): **Af = (WQv) x (df)/ [(k) x (hf+df) x (tf)]** • WQv = water quality volume (cu. ft) • df = filter bed depth (ft) • k = coefficient pf permeability of the filter bed (ft/day) • hf = height of water above the filter bed (ft) • tf = design filter bed drain time (days)- 2 days recommended
☐	PC 19.4	Pretreatment includes ensuring a 2 ½ to 4 foot deep planting soil bed, a surface mulch layer, and a 12" deep surface ponding area.
☐	PC 19.5	The ponding depth should be 6 inches or less with a mulch layer of 2 to 3 inches.
☐	PC 19.6	Overflow for the ten-year storm event shall be provided to a non-erosive outlet point and non-erosive velocities shall result.
☐	PC 19.7	A flow regulator shall be provided to divert the water quality volume to the filtering practice.
☐	PC 19.8	The filters shall have a 6 inch perforated under drain pipe in a gravel layer.
☐	PC 19.9	A permeable filter fabric shall be places between the gravel layer and the filter media.
☐	PC19.10	Landscaping is critical to the function and performance of the bioretention areas. A landscaping plan shall be provided for these areas including dense and vigorous vegetation.

*Example Bioretention attached.

Figure 7. Schematic for Bioretention Filter



Bioretention combines open space with stormwater treatment.

Source: Maryland Department of the Environment. 2000.

Permanent Best Management Practices
PC20: Sand Filters

Description

Sand filters are usually designed as two-chambered storm water practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As storm water flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as storm water flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).

Potential Pollutant Treatment

Review the manufacturer's specifications to determine the pollutants that may be removed with this device. In general, it will address total suspended solids and turbidity.

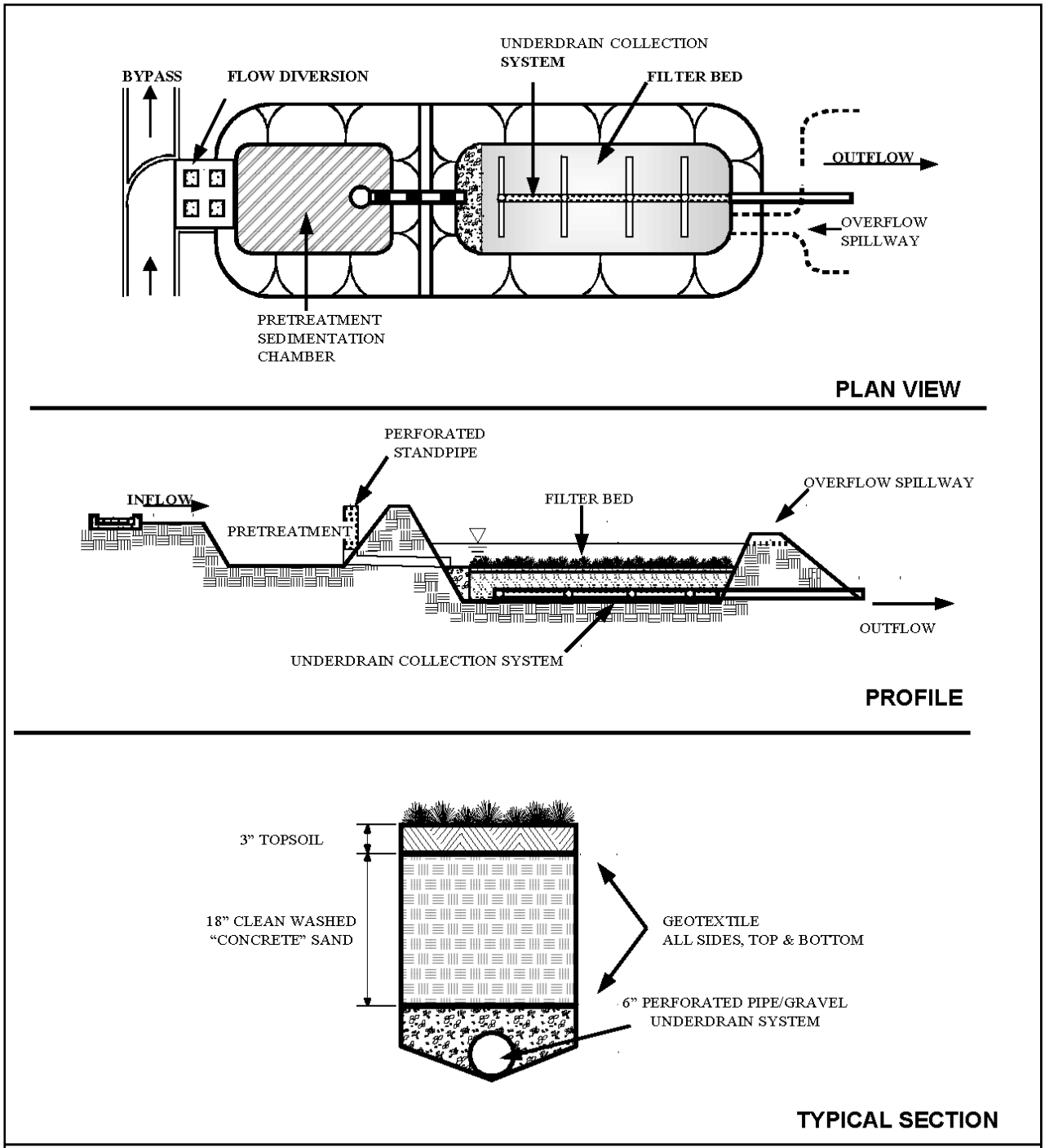
Limitations

- Sand filters cannot control floods and generally are not designed to protect stream channels from erosion or to recharge the ground water.
- They require frequent maintenance, and underground and perimeter versions of these practices are easily forgotten because they are out of sight.
- They cannot be used to treat large drainage areas.
- Surface sand filters are generally not aesthetically pleasing practices but underground and perimeter sand filters are not visible, and thus do not add or detract from the aesthetic value of a site.

Practice		
☐	PC 20.1	Sand filters are best applied on relatively small sites (up to 10 acres for surface sand filters and closer to 2 acres for perimeter or underground filters.
☐	PC 20.2	They require an elevation drop, or head (about 5 to 8 feet), to allow flow through the system.
☐	PC 20.3	Provide at least 2 feet of separation between the bottom of the filter and the seasonally high ground water table to prevent damage to the filter and ground water contamination.
☐	PC 20.4	Pretreatment is achieved in the sedimentation chamber that precedes the filter bed. In this chamber, the coarsest particles settle out; this prevents clogging as the particles do not reach the filter bed.
☐	PC 20.5	Provide at least 25 percent of the water quality volume in a dry or wet sedimentation chamber as pretreatment to the filter system.
☐	PC 20.6	The water quality volume is the amount of runoff that will be treated for pollutant removal in the practice. Typical water quality volumes are the runoff from a 1-inch storm or ½ inch of runoff over the entire drainage area to the practice.
☐	PC 20.7	To determine the amount of runoff that will be treated for pollutant removal, calculate flow to determine water quality flow rate (cfs): **WQFR = C x 0.4" x A** • WQFR = water quality flow rate in cubic feet per second • C = runoff coefficient (C =0.8 for pervious surface, C= 0.9 for impervious surface). • A = area of the site in acres • 0.4" = hourly rainfall intensity
☐	PC 20.8	Calculate the required filter bed area (Af): **Af = (WQv) x (df)/ [(k) x (hf+df) x (tf)]** • WQv = water quality volume (cu. ft) • df = filter bed depth (ft) • k = coefficient pf permeability of the filter bed (ft/day) • hf = height of water above the filter bed (ft)

		• tf = design filter bed drain time (days)- 2 days recommended
☐	PC 20.9	Provide at least 75 percent of the water quality volume in the practice including both the sand chamber and the sediment chamber.
☐	PC20.11	Construct an under drain, which is a perforated pipe system in a gravel bed that is installed on the bottom of filtering practices and used to collect and remove filtered runoff.
☐	PC20.12	Use a flow splitter, which is a structure that bypasses larger flows to the storm drain system or to a stabilized channel during larger storms.

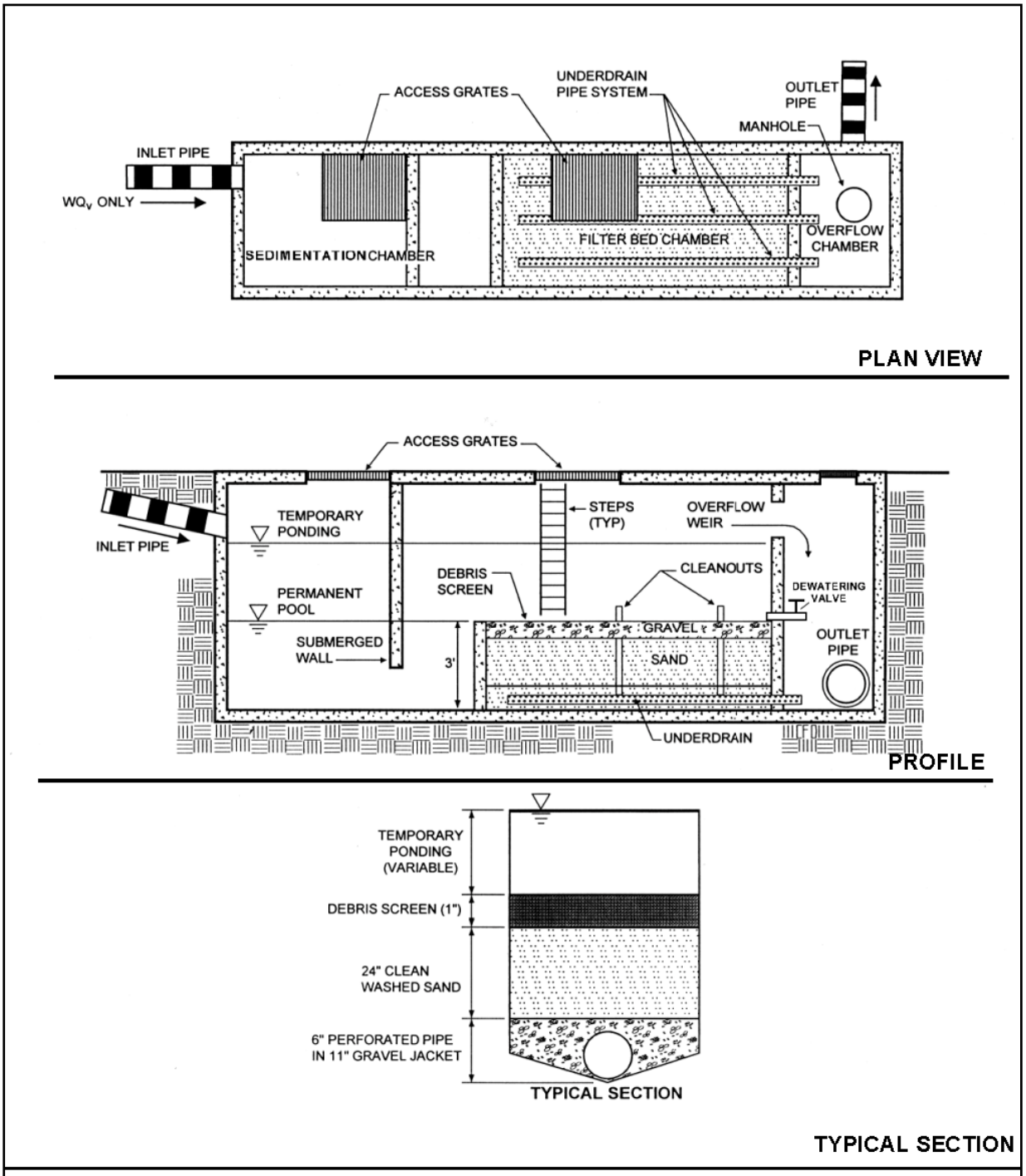
Figure 8. Schematic for Surface Sand Filter



Surface sand filters can treat the largest drainage area of all the filtering systems.

Source: Maryland Department of the Environment. 2000.

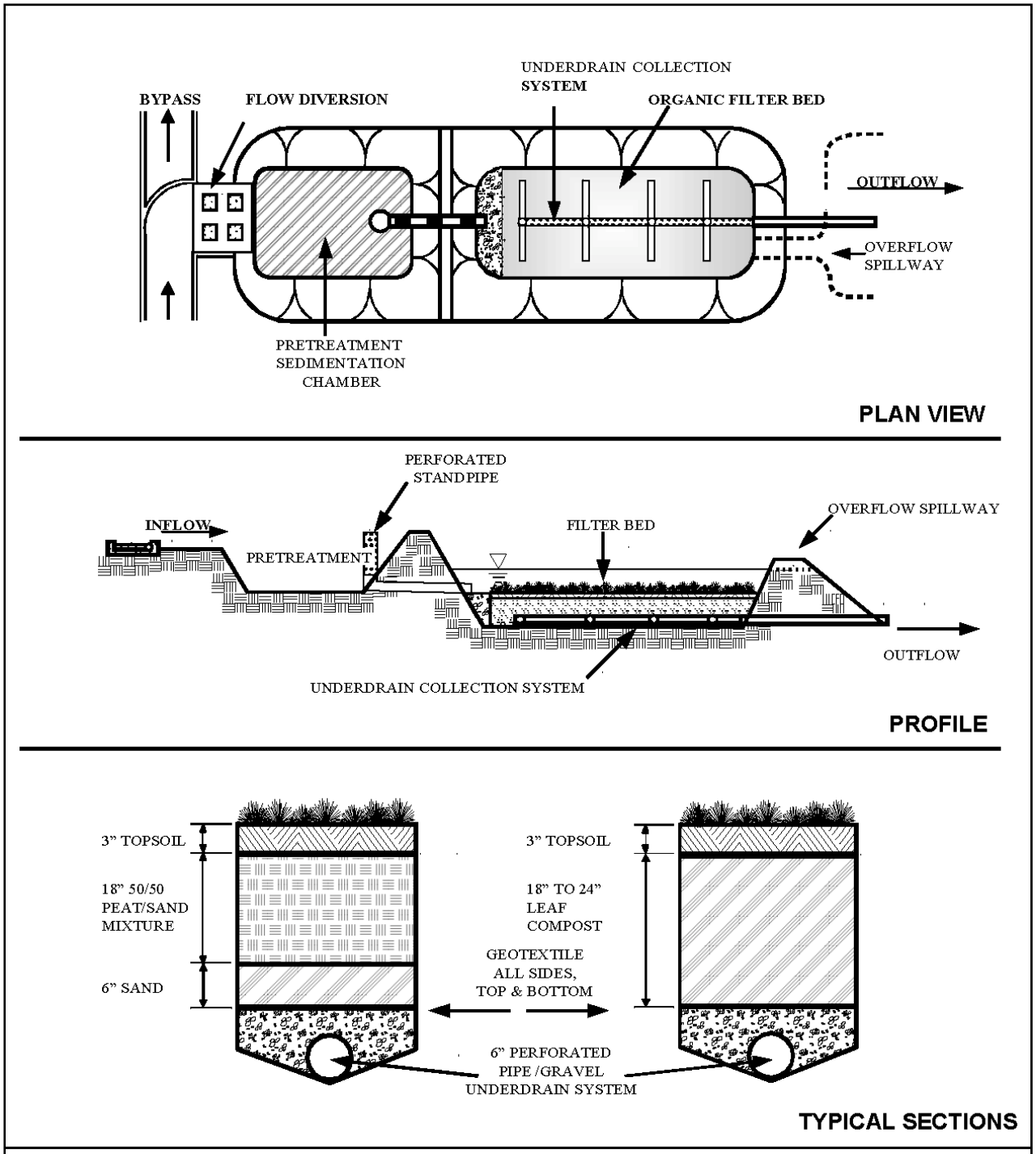
Figure 9. Schematic for Underground Sand Filter



The underground sand filter is an option for providing WQ_v where space is limited.

Source: Maryland Department of the Environment. 2000.

Figure 10. Schematic for Organic Sand Filter



The organic filter is used when maximum nutrient or trace metal removals are desired.

Source: Maryland Department of the Environment. 2000.

Permanent Best Management Practices
PC21: Oil Water Separator

Description

Oil water separators are permanent treatment control devices designed to remove contaminants. The conventional separator and the coalescing plate interceptor (CPI) are two commonly used oil water separators. The primary function of oil water separators is to specifically remove petroleum compounds, other floatable debris, and settleable solids. Conventional separators are capable of removing oil droplets with diameters greater than 150 microns. CPI separators are used when droplets smaller than 150 microns must be removed.

Potential Pollutant Treatment

This BMP addresses petroleum products such as gasoline, diesel, jet fuel, and used oil.

Limitations

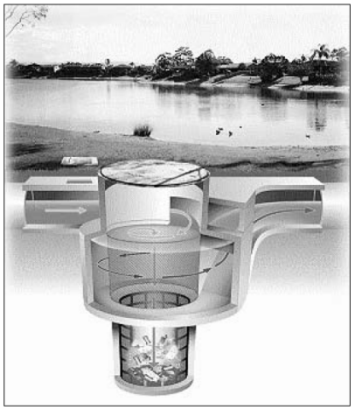
- The design loading rate for oil water separators is low, therefore, they can only be cost-effectively sized to detail and treat nuisance and low flows (small storm or first flush events). Sizing to accommodate an average to larger storm results in a large sized facility and is not economical.
- The typically low concentrations of oil in most storm water results in considerable performance uncertainty.
- Oil water separators require frequent inspection and routine maintenance for the life of the structure.

Practice		
☐	PC 21.1	Determine the size of separators based on rate of runoff, rise-rate velocity of the oil droplets, and the settling rate of solids to be removed.
☐	PC 21.2	Oil water separators shall be sized to treat first flush of runoff, which larger storms diverted around the separator.
☐	PC 21.3	Determine type of separator, CPI or conventional. CPI separator contains closely spaced plates that enhance the removal efficiency.
☐	PC 21.4	Oil water separators shall be inspected at least semi-annually and following significant storm events.

Permanent Best Management Practices
PC22: Continuous Deflective Separation (CDS)

Description

Continuous Deflective Separation (CDS) technologies direct solid pollutants into the lower catchment chamber and the floatables to the surface of the upper chamber using a non-mechanical, non-blocking screen technology. It is most often used for grow pollutant removal. The system utilizes the natural motion of water to separate and trap sediments by direct infiltration. As storm water flows through the system, a very fine screen deflects the pollutants, which are captured in a litter sump in the center of the system.



Potential Pollutant Treatment

Review the manufacturer's specifications to determine the pollutants that may be removed with this device. In general, it will address total suspended solids and turbidity.

Limitations

The system does not rely on secondary flow currents induced by vortex action.

Practice		
☐	PC 22.1	To determine the amount of runoff that will be treated for pollutant removal, calculate flow to determine water quality flow rate (cfs): **WQFR = C x 0.4" x A** • WQFR = water quality flow rate in cubic feet per second • C = runoff coefficient (C =0.8 for pervious surface, C= 0.9 for impervious surface). • A = area of the site in acres • 0.4" = hourly rainfall intensity
☐	PC 22.2	A porosity value "n" (n=Vv/Vt) of 0.40 should be used in the design of stone reservoirs for infiltration methods.
☐	PC 22.3	Processing capabilities vary from 3 to 300 cubic feet per second.
☐	PC 22.4	Pre-cast modules are available for flows up to 62 cubic feet per second, while higher flow processing requires cast-in-place construction.
☐	PC 22.5	Every unit requires a detailed hydraulic analysis before installation to ensure optimum solids separation is achieved.
☐	PC 22.6	There are no specific landscaping requirements. Areas around CDS units should be clear at the surface and accessible for maintenance and inspection purposes.
☐	PC 22.7	Aggressive maintenance plans are required to reduce the risk of re-suspension of sediment during large storm events.
☐	PC 22.8	Manholes should be included for each chamber for cleaning access.
☐	PC 22.9	Inlets should be inspected and cleaned after every major storm event and inspected monthly.
☐	PC22.10	Oil water separators may be used in conjunction with CDS units to remove oils.
☐	PC22.11	CDS units should be inspected every 6 months and cleaned where necessary.
☐	PC22.12	Catch basin cleaning equipment can be used, but manual sediment removal may be required as well.
☐	PC22.13	Amount of material removed from each chamber should be documented. Disposal of waste should be done according to material contents and disposal requirements.

Construction Activities Best Management Practices
PC23: Storm Drain Inlet Protection

Description
Devices of various designs which detain sediment-laden runoff and allow the sediment to settle out of the water prior to discharge into a storm drain inlet or catch basin.

Potential Pollutant Treatment
Review the manufacturer's specifications to determine the pollutants that may be removed with this device. In general, it will address total suspended solids and turbidity.

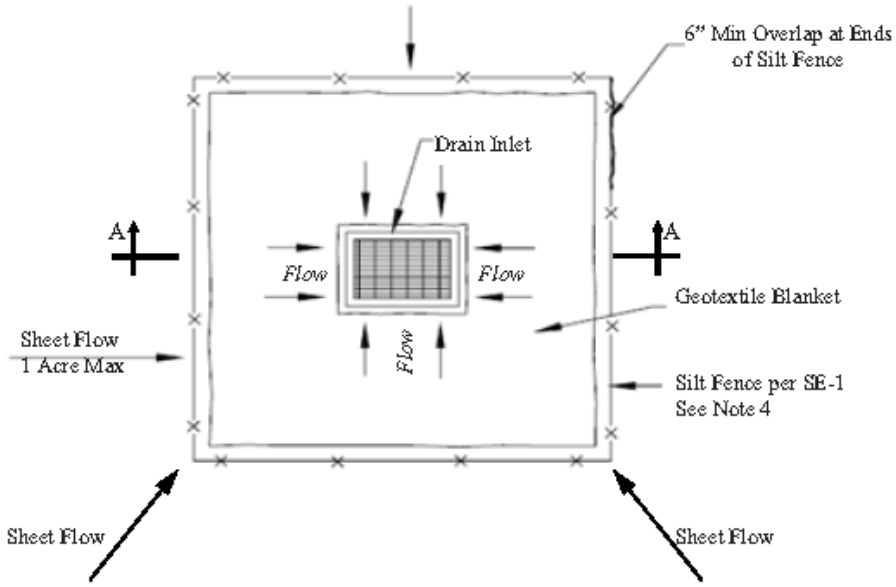
Limitations
- Inlet protection must not create a potential hazard to traffic.
- Drainage area should not exceed 1 acre.
- Ponding will occur at a protected inlet, with possible short term flooding.
- Straw bales are NOT effective for inlet protection.

Practice		
☐	PC23.1	Every storm drain inlet potentially receiving sediment-laden runoff shall be protected, either by covering the inlet or promoting sedimentation upstream of the inlet.
☐	PC23.2	Five types of inlet protection are presented below; however, other effective methods and proprietary devices exist and may be selected: • Filter Fabric Fence: Appropriate for drainage basins less than one acre with less than a 5 percent slope. • Block and Gravel Filter: Appropriate for flows greater than 0.5 cubic feet per second (cfs). • Gravel and Wire Mesh Filter: Used on curb or drop inlets where construction equipment may drive over the inlet. • Sand Bag Barrier: Used to create a small sediment trap upstream of inlets on sloped, paved streets. • Excavated Drop Inlet Sediment Trap: An excavated area around the inlet to trap sediment.
☐	PC23.3	Inlet protection must be of sufficient strength and permeability to allow storm water to pass through and retain sediment. Must be anchored such that the material will not fall into the drain when the grate is removed for maintenance.
☐	PC23.4	Only for drainage areas smaller than one acre unless a sediment trap first intercepts the runoff.
☐	PC23.5	Provide area around the inlet for water to pond without flooding structures and property.

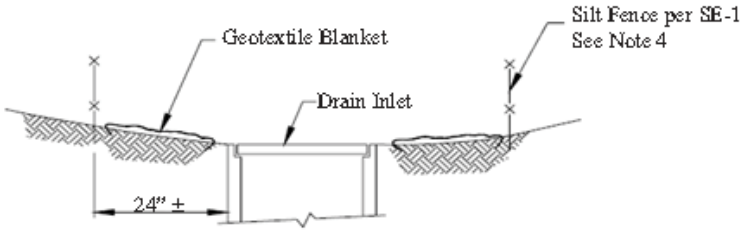
Note: Example schematics for inlet protection are included herein for reference.

Maintenance and Inspection		
☐	PC23.1	Inspect inlet protection devices prior to an anticipated rainfall event, after the rainfall event, and regularly at the end of each work week. During extended rainfall events inspect inlet protection devices daily.
☐	PC23.2	Repair damage sustained to the inlet protection devices within two (2) calendar days after the incident or before the next anticipated rainfall event, whichever comes first.
☐	PC23.3	Remove sediment after each rainfall event and once the containment device is ½ full of sediment.
☐	PC23.4	Provide education for required personnel about storm drain protection from sediment discharge and other construction site contaminants.

Figure 11. Storm Drain Inlet Protection - Filter Fabric Fence



Detail "A"
Not to Scale



Section A-A
Not to Scale

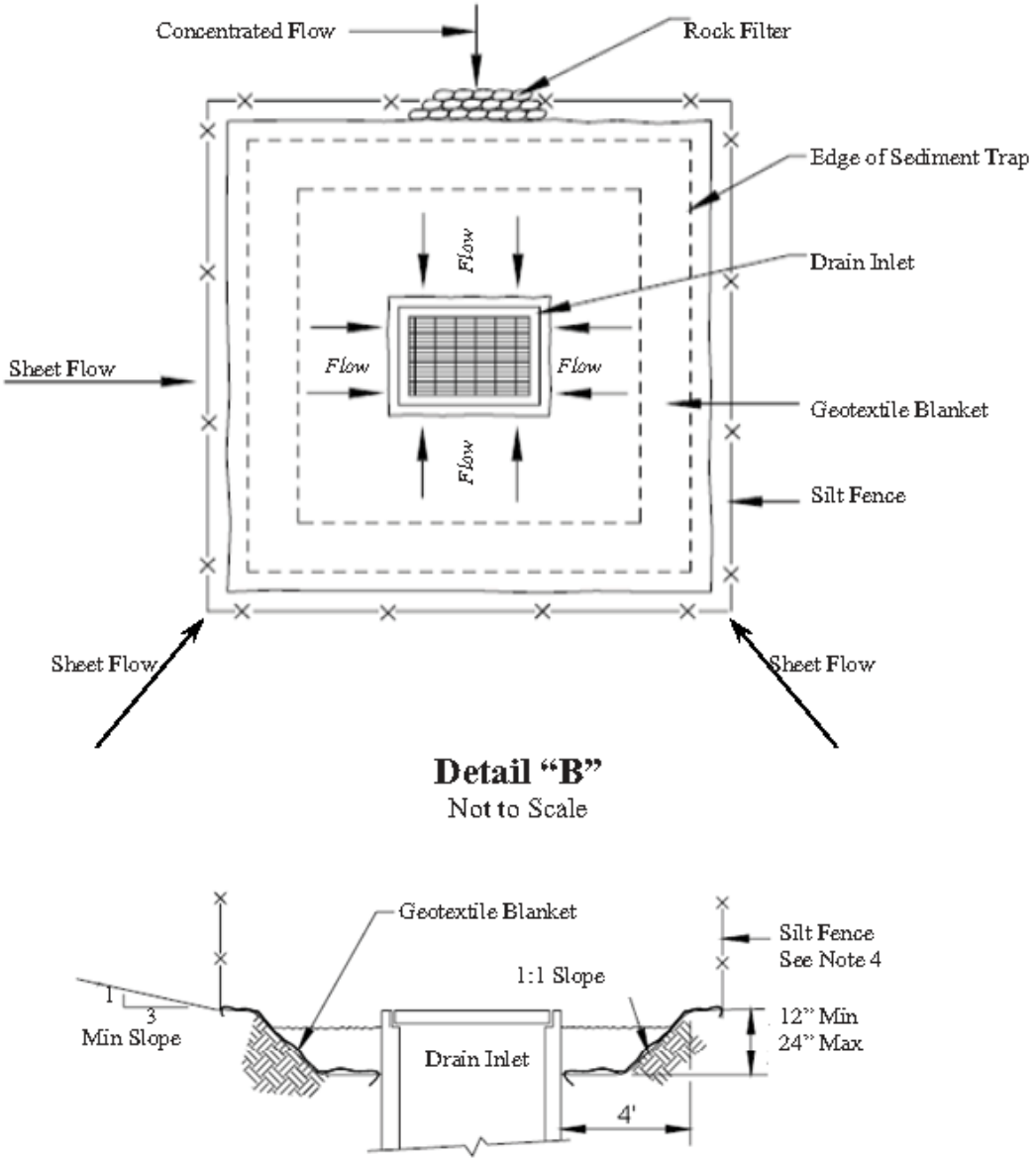
Notes:

1. For use in areas where grading has been completed and final soil stabilization and seeding are pending.
2. Not applicable in paved areas.
3. Not applicable in concentrated flows.
4. Refer to BMP SE-1, Silt Fence for construction.

Source: City and County of Honolulu BMP Manual, November 2011.

DI Protection Type 1, Filter Fabric Fence

Figure 12. Storm Drain Inlet Protection – Sediment Trap



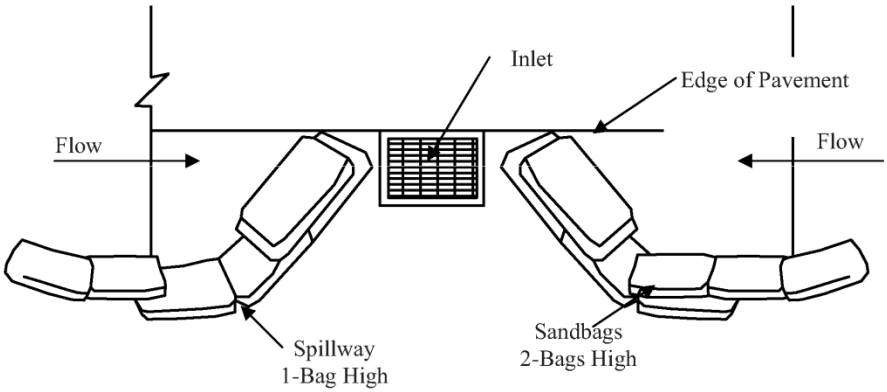
Notes:

1. For use in cleared and grubbed and in graded areas.
2. For concentrated flows, shape basin in 2:1 (L:W) ratio with length oriented towards direction of flow.
3. Size excavated trap to provide a minimum storage capacity calculated at the rate 67 yd^3/acre of drainage area.
4. Refer to BMP SE-1, Silt Fence for construction.

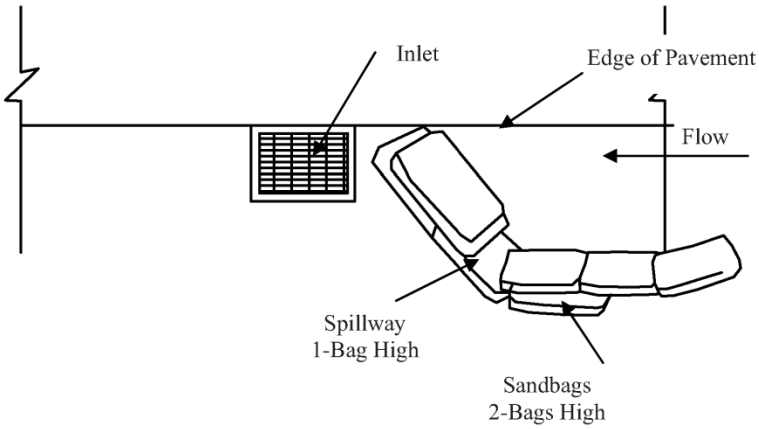
DI Protection Type 2, Excavated Drop Inlet Sediment Trap

Source: City and County of Honolulu BMP Manual, November 2011.

Figure 13. Storm Drain Inlet Protection – Gravel Bag



Typical Protection for Inlet on Sump, Detail "C"
Not to Scale



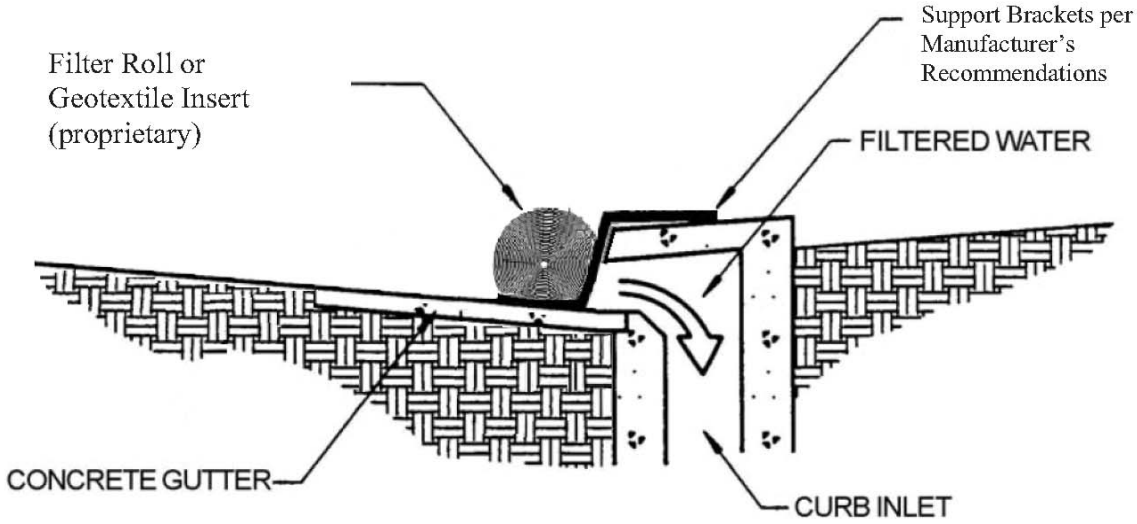
Typical Protection for Inlet on Grade, Detail "D"
Not to Scale

Notes:
1. Intended for short-term use. Not suitable for roads open to traffic.
2. Used to inhibit non-storm water flow.
3. Bags **should** be removed after adjacent operation is completed.
4. Not applicable in areas with high silts and clays without filter fabric.
5. Use sand bag made of geotextile fabric (not burlap) and fill with 0.75 in. rock or 0.25 in. pea gravel.
6. Construct on gently sloping street.
7. Leave room upstream of barrier for water to pond and sediment to settle.
8. Place several layers of sand bags - overlapping the bags and packing them tightly together.
9. Leave gap of one bag on the top row to serve as a spillway. Flow from a severe storm (e.g., 10 year storm) should not overtop the curb.
10. Do not use sandbags for roadways subject to traffic.
11. For traffic area, insert geotextile filter inserts instead of sandbags.

DI Protection Type 3, Gravel Bag

Source: City and County of Honolulu BMP Manual, November 2011.

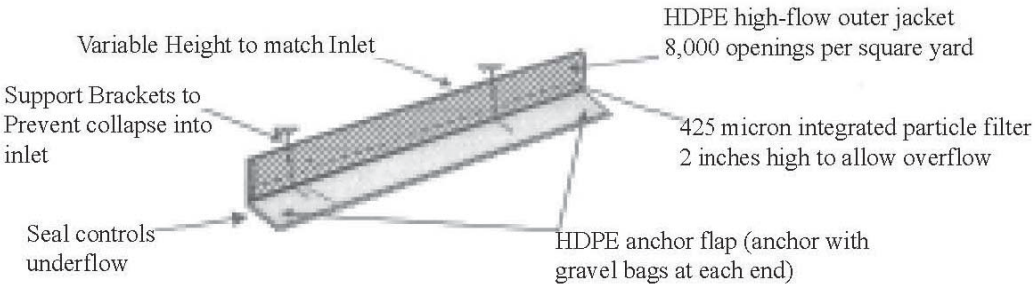
Figure 14. Storm Drain Inlet Protection - Geotextile



Detail "F"

Not to Scale and May Use Various Types of Geotextile Inserts

DI Protection Type 5, Filter Roll or Geotextile Insert with Supports for Curb Inlet



Detail "G"

Not to Scale and May Use Various Types and Styles of Geotextile Inserts

DI Protection Type 5, Geotextile Insert with Supports for Curb Inlet

Source: City and County of Honolulu BMP Manual, November 2011.

Construction Activities Best Management Practices
PC24: Underground Detention Basin

Description

Detention basins can provide storm water volume control and are normally used for sites where developable surface area is at a minimum. There are several designs for underground detention facilities, and all methods serve as alternatives to surface dry detention for storm water quantity control. Furthermore detention basins contain flow and retain the water until it can be released slowly over the course of a period of time. This method decreases peak flows and reduces flooding problems.

Potential Pollutant Treatment

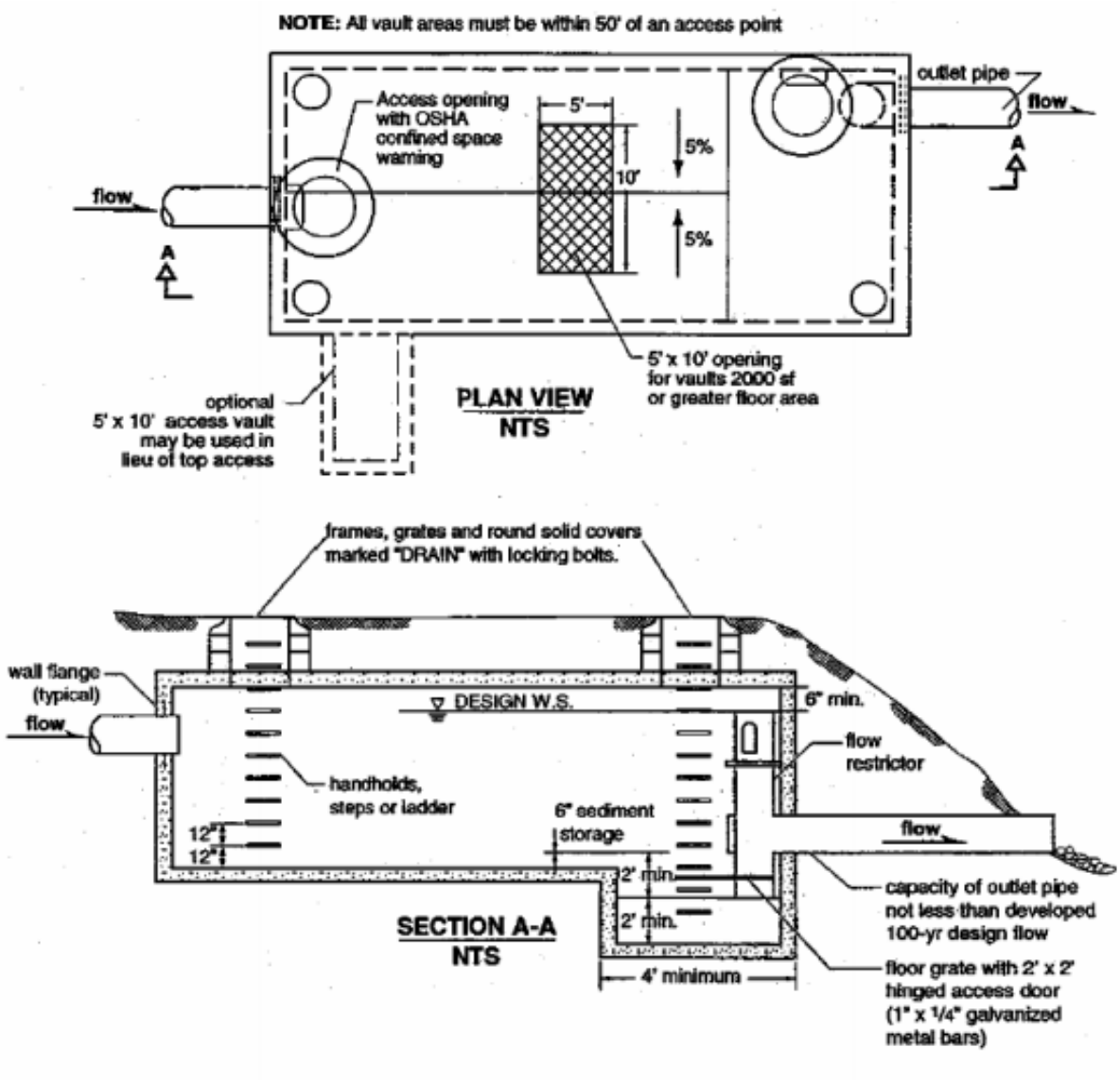
Review the manufacturer's specifications to determine the pollutants that may be removed with this device. In general, it will address total suspended solids and turbidity.

Limitations

- These systems may require more excavation than surface ponds or wetlands.
- Frequent maintenance is required.

Practices		
☐	PC24.1	The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres.
☐	PC24.2	The general design shall consist of the following elements: • An outlet structure; • An emergency spillway; and • Maintenance access.
☐	PC24.3	Routing calculations must be used to demonstrate that the storage volume is adequate.
☐	PC24.4	Underground vaults and tanks must meet structural requirements for overburden support and traffic loading.
☐	PC24.5	Flood protection controls for peak discharge control, should be designed as final controls for on-site storm water. Underground detention will typically be located downstream of structural storm water BMPs that are designed to provide treatment of the water quality volume and channel protection volume.
☐	PC24.6	The drainage easement shall be located 15 feet from the outside limits of the underground detention structure. The first floor elevation for any structure adjacent to the underground detention shall have an elevation no lower than 1 foot above the emergency spillway elevation.
☐	PC24.7	Water shall not be discharged from underground detention in an erosive manner. Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the end of the outlet to prevent scouring and erosion.
☐	PC24.8	A high flow bypass shall be included in the underground detention design to address instances of significant rainfall, outlet structure blockage, or mechanical failure. The bypass shall be located so that downstream structures will not be impacted by emergency discharges.
☐	PC24.9	Adequate maintenance access must be provided for all underground detention systems. Access must be provided over the inlet pipe and outflow structure. Access openings can consist of a standard frame, grate and solid cover, or a removable panel.

Figure 16. Underground Detention Basin



Source: Knox County Tennessee Stormwater Management Manual, Volume 2, January 2008.

Construction Activities Best Management Practices
PC25: Storm Water Harvesting

Description
Various methods may be used to capture or harvest storm water from the small scale (e.g. rain barrels) to the large scale, (e.g. underground detention basins (PC24)). Captured water may then be reused for irrigation purposes, water features, or other non-potable purpose, which will result in a reduction or elimination of storm water runoff and associated potential pollutants being discharged to the MS4.

Potential Pollutant Treatment
This BMP provides a high level of treatment for most targeted pollutants with the exception of trash and debris (e.g. nutrients, sediment, bacteria, pesticides, oil & grease, metals, and organic compounds).

Limitations
- Additional filtration may be required before reuse.

Practices		
☐	PC25.1	Determine whether there is a need for captured runoff, such as irrigation or water features.
☐	PC25.2	Disconnect downspouts and/or direct facility drains to the capture device.
☐	PC25.3	Appropriately size the device as directed in the City and County of Honolulu, Storm Water BMP Guide.
☐	PC25.4	Sample the water collected to ensure that it will be safe for re-use. Compare sample results to HAR 11-54 limitations. *Note if parameters are exceeded, additional filtration systems may be necessary.
☐	PC25.5	Roof gutter guards or screens may be required to reduce clogging from sediment, leaves, and other organic material.
☐	PC25.6	High flow bypass may be necessary for the containment device. The bypass shall be located so that downstream structures will not be impacted by emergency discharges.
☐	PC25.7	Adequate maintenance access must be provided to the containment device.

Construction Activities Best Management Practices
PC26: Fueling Area Design

Description
Spills or releases are a common occurrence at fueling areas due to the nature of the activity and the materials being stored. This BMP includes design recommendations to mitigate those potential impacts.

Potential Pollutant Source Control
This BMP is designed to control petroleum products such as gasoline, diesel, aviation gasoline, and jet fuel.

Limitations
- Asphalt may not be used to pave area.
- Additional requirements from 40 CFR 112 (SPCC) may apply.
- Covers may limit the size of aircraft, vehicle, or equipment that may be fueled.

Practices		
☐	PC26.1	Add a cover or roof structure over the fuel dispensing area.
☐	PC26.2	Route downspouts such that runoff will not flow through the dispensing area.
☐	PC26.3	Pave with Portland cement or equivalent impervious surface from fuel dispenser to 1 ft past where the dispensing nozzle may reach.
☐	PC26.4	Consider adding a berm to the area such that any spills during fueling will be contained. Speed bumps may be utilized in areas where vehicles need to enter and exit the fueling area. Include a discharge drain that may be locked for the bermed area to allow for the release of accumulated, uncontaminated storm water.
☐	PC26.5	Designate a location where a spill kit will be maintained and post associated signs.
☐	PC26.6	Designate an appropriate location for the emergency shut-off in an easily accessible area, but a sufficient distance from the fuel pumps for safety purposes. Post signs indicating the location of the emergency shut-off.

Construction Activities Best Management Practices
PC27: Maintenance Area Design

Description
Aircraft, vehicle, and equipment maintenance may result in the generation of a variety of potential pollutants. This BMP includes design recommendations to mitigate those potential impacts.

Potential Pollutant Source Control
This BMP is designed to control potential pollutants associated with maintenance activities such as petroleum products, solvents, metals, paints, antifreeze, and other vehicle fluids.

Limitations
- Covers may limit the size of aircraft, vehicle, or equipment that may be serviced.
- Connections to the sanitary sewer may require additional permits.

Practices		
☐	PC27.1	Locate maintenance areas indoors or under cover.
☐	PC27.2	Pave maintenance floor areas with Portland cement or equivalent.
☐	PC27.3	Provide impermeable berms, trench drains, or other containment system around the maintenance area to contain any spilled materials. Connect trench drains to sumps or to the sanitary sewer through oil water separators as applicable.
☐	PC27.4	Locate spill clean-up materials in or near the maintenance area.
☐	PC27.5	Designate locations for material and waste storage. Use secondary containment for liquids and batteries.

Construction Activities Best Management Practices
PC28: Washing Area Design

Description
Aircraft, vehicle, and equipment washing may result in the generation of a variety of potential pollutants. This BMP includes design recommendations to mitigate those potential impacts.

Potential Pollutant Source Control
This BMP is designed to control potential pollutants associated with washing activities such as surfactants, sediment, petroleum products, metals, paints, antifreeze, and other vehicle fluids.

Limitations
- Covers may limit the size of aircraft, vehicle, or equipment that may be washed.
- Connections to the sanitary sewer may require additional permits.

Practices		
☐	PC28.1	Design the area to be contained. This may include grading the site to a central drain, placing berms around the perimeter, locating it indoors, or some other containment method.
☐	PC28.2	Include a wash water treatment device, such as an oil water separator.
☐	PC28.3	Consider recycling the water after filtration and/or direct excess to the sanitary sewer.
☐	PC28.4	Clearly mark the wash area and post signs about approved washing practices.
☐	PC28.5	Consider covering the wash area to minimize contact with storm water.
☐	PC28.6	Prevent storm water runoff from flowing through the wash area to the extent practicable.

Construction Activities Best Management Practices
PC29: Loading Area Design

Description
The loading and unloading of materials may result in a variety of potential pollutants if the materials were to spill. This BMP includes design recommendations to mitigate impacts from those pollutants.

Potential Pollutant Source Control
This BMP is designed to control potential pollutants associated with loading such as trash and debris. Additional pollutants may be controlled dependent upon the material being loaded.

Limitations
- Covers may limit the size of aircraft, vehicle, or equipment that may be loaded.

Practices		
☐	PC29.1	Designate a loading area.
☐	PC29.2	Cover all loading dock areas or design them to preclude run-on and runoff.
☐	PC29.3	Direct downspouts such that runoff does not flow through the loading area.
☐	PC29.4	Do not located storm drains in the immediate vicinity of the waste storage area.
☐	PC29.5	Do not allow runoff from below grade loading docks to enter the storm drain system. Ensure that is a separate drain and treatment system used for those areas.
☐	PC29.6	Pave loading areas with concrete instead of asphalt.

Construction Activities Best Management Practices
PC30: Waste Management Area Design

Description
Waste management can result in a variety of contaminants to the storm water runoff. Specifically, pollution may occur when loose trash and debris is transported in the wind or runoff or when waste containment devices leak. This BMP includes designs to mitigate the impact from waste storage and disposal.

Potential Pollutant Source Control
This BMP is designed to control potential pollutants associated with loading such as trash and debris. Additional pollutants may be controlled dependent upon the waste being loaded.

Limitations
- None.

Practices		
☐	PC30.1	Designate a waste area that is out of the path of storm water flow.
☐	PC30.2	Direct downspouts such that runoff does not flow through the waste storage area.
☐	PC30.3	Prevent rainfall from entering containers with roofs, awnings, or attached lids.
☐	PC30.4	Pave storage areas with an impervious surface to allow for easier remediation of spills.
☐	PC30.5	Do not located storm drains in the immediate vicinity of the waste storage area.
☐	PC30.6	Post signs on individual containers to indicate the types of wastes that can be disposed therein.
☐	PC30.7	Reduce and/or prevent releases from trash containers by using lined bins, a containment berm around the dumpster, or drip pans beneath the bin.
☐	PC30.8	Ensure that all liquid wastes (e.g. used oil and batteries) are stored within secondary containment.

Construction Activities Best Management Practices
PC31: Material Storage Area Design

Description
The proper design of a material storage location will reduce the potential for pollutants to impact the storm water runoff or MS4. Due to spill materials that may occur in these areas, BMPs center on containment.

Potential Pollutant Source Control
The pollutants controlled by this BMP will be dependent upon the type of material stored.

Limitations
- None.

Practices		
☐	PC31.1	Design storage area to be indoors or under cover. For areas that must be uncovered, contain the site with a berm, trench drain, or other system.
☐	PC31.2	Pave the storage area with Portland cement or equivalent to contain releases.
☐	PC31.3	Ensure that spill kit is kept in the area.
☐	PC31.4	Use secondary containment for liquid materials and batteries. This may include spill pallets, flammable storage lockers, double-walled tanks, or other method.
☐	PC31.5	Provide a method for inspection of the secondary containment and clean-up/discharge of spill material and/or storm water that may accumulate.
☐	PC31.6	Post signs indicating where particular materials will be stored.
☐	PC31.7	Use containment for stockpile kept on-site for more than a day. Containment may include berms, silt fence, concrete walls, or designated bins.

REFERENCES

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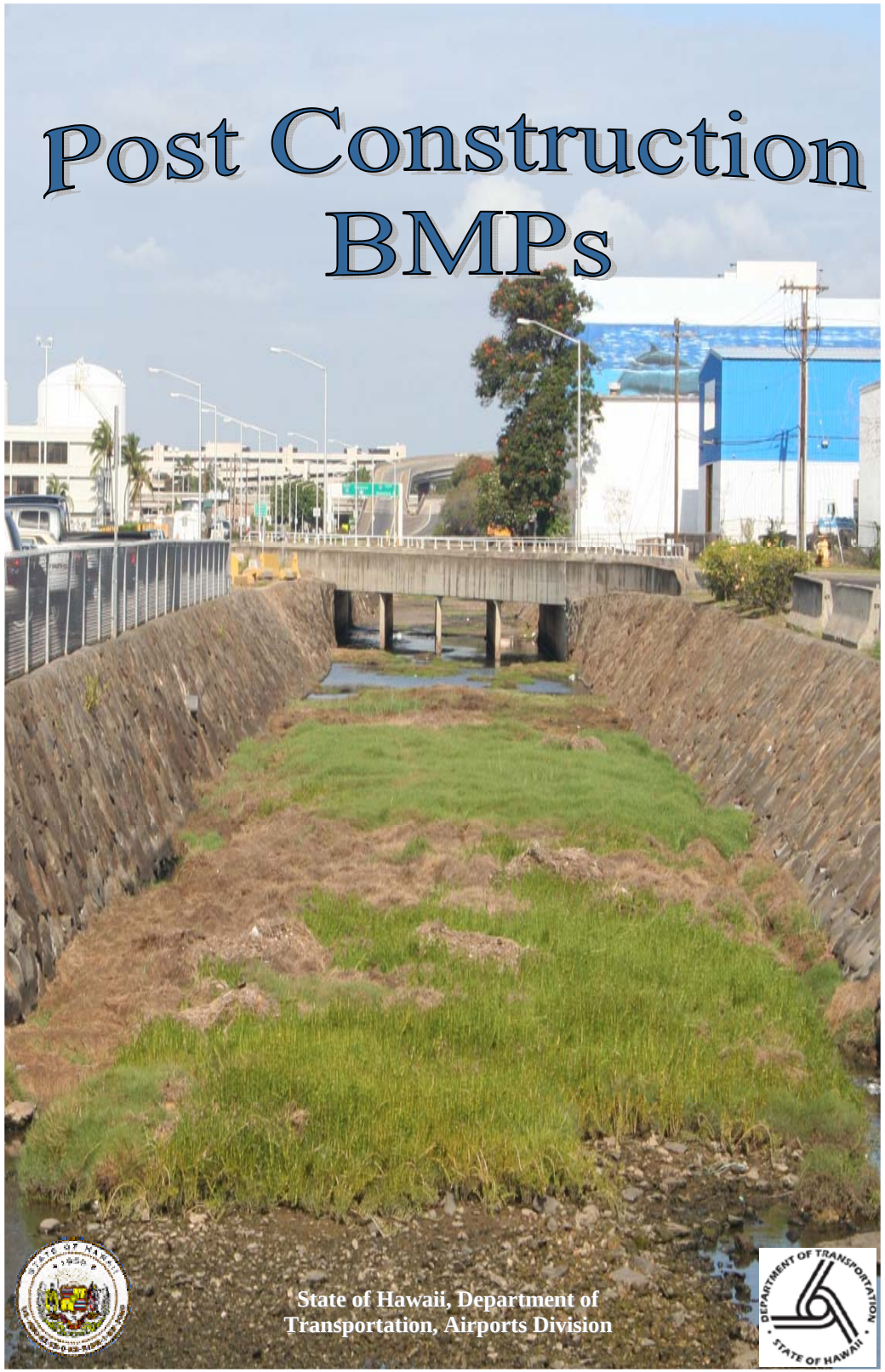
Attachment D.2

Post-Construction BMP Handout

Post Construction BMPs



State of Hawaii, Department of Transportation, Airports Division

Storm Water Treatment BMP Design

Components

- Flow Regulation - diversion of storm water to and from BMP
- Pretreatment - trapping of coarse sediments to extend design lift
- Filter Bed and Filter Media - primary component of facility
- Outflow / Overflow - Safe conveyance of all storms through facility

Unified Sizing Criteria

Calculate Water Quality Volume (WQ_v):

$$\mathbf{WQ_v = (P) \times (R_v) \times (A)/12} \quad \text{(acre-feet)}$$

OR

$$\mathbf{WQ_v = (P) \times (R_v) \times (A) \times 3630} \quad \text{(cfs)}$$

where

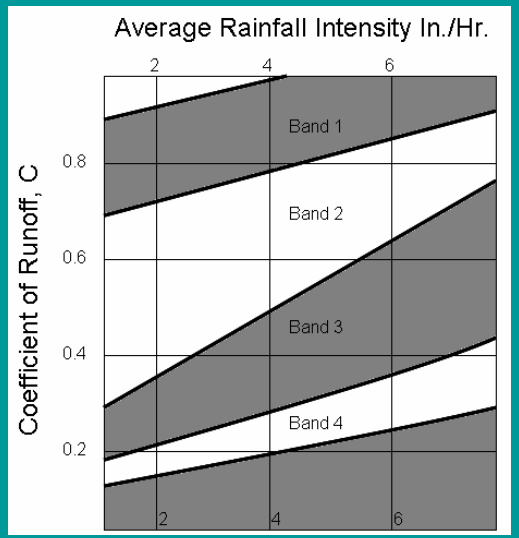
- P = rainfall depth (inches), usually 0.4 inches
- R_v = runoff coefficient
- A = drainage area (acres)

The runoff coefficient can be obtained from the following equation:

$$R_v = 0.05 + 0.009(I), \text{ where I = percent impervious}$$

OR

The runoff coefficient can be obtained from the figure below (likely from Band 1):



Band 1: Steep, barren, impervious surfaces
Band 2: Rolling barren in upper band values, flat barren in lower part of band, steep forested and steep grass meadows
Band 3: Timber lands of moderate to steep slopes, mountainous, farming
Band 4: Flat pervious surface, wooded areas

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Design Process

Best Management Practices

- Pollutant Controls
- Reduce Runoff
- Treat Polluted Runoff

Permit Requirements

Storm Water Treatment BMP Design

Required Filter Bed Area (Af):

Af = (WQv) x (df)/ [(k) x (hf+df) x (tf)]

where

- WQv = water quality volume (cu. ft)
- df = filter bed depth (ft)
- k = coefficient of permeability of the filter bed (ft/day)
- hf = height of water above the filter bed (ft)
- tf = design filter bed drain time (days)- 2 days recommended

Some common values of k are:

Sand 3.5 ft/day	Peat 2 ft/day
Leaf Compost 8.7 ft/day	Bioretention Soil 0.5 ft/day

Required Filter Bed Depth (d_{max}):

$$d_{max} = (f \times T_s) / n$$

where

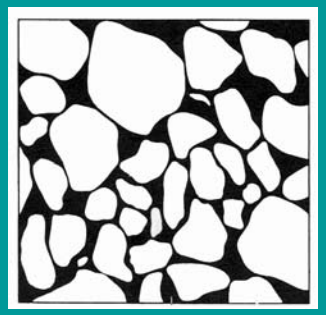
- f is the infiltration rate (inches / hour)
- T_s is the maximum allowable storage time (hours), use 48 hours
- n is the porosity of the medium, use 0.4 for stone reservoirs

Porosity Calculation:

$$n = V_v / V_t$$

Where

- V_v is the voids volume
- V_t is the total volume



KEY TERMS

303(d) List - The Clean Water Act, Section 303(d) states that each State needs to compile a list of their impaired waters, taking into account the severity of the pollution and the uses to be made of such waters. The list is then submitted to Congress every two years. The State must also determine which pollutants are causing the impairment and set Total Maximum Daily Loads (TMDL) for that contaminant.

Best Management Practice (BMP) - 40 CFR 122.2 states that BMP means "schedules of activities, prohibitions or designations of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of 'waters of the United States.'"

Detention Volume - The volume of runoff that is held and treated in a BMP strucutre.

Discharge Rate - The rate at which water is discharged out of the BMP after being stored and treated.

Drainage Area - The drainage area (aka drainage basin or watershed) consists of an extent of land where the majority of the storm water runoff flows to an outlet point.

Erosion - The wearing away of the land surface by wind or water. Erosion occurs naturally for weather or runoff but can be intensified by land-clearing practices related to development.

Freeboard - The vertical distance between the water surface of the design discharge and a point of interest such as the top of a containment structure.

Hydrologic Cycle - The cycle of water movement from the atmosphere to the earth and returning to the atmosphere through various stages or processes such as precipitation, interceptions, runoff, infiltration, percolation, storage, evaporation, and transportation.

Impervious Surface - A hard surface area that either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. Common impervious surfaces include, but are not limited to, rooftops and pavements.

Land Disturbing Activity - Any activity that results in a change in the existing soil cover (both vegetative and non-vegetative) and/or the existing soil topography. Common land disturbing activities include, but are not limited to, demolition, construction, clearing, grading, filling, and excavation.

Municipal Separate Storm Sewer System (MS4) - A system of storm drains, channels, streams, and other water conveyance structures, owned by the State, that are used for collecting and conveying storm water to the receiving water.

INFILTRATION TRENCH

Description

The infiltration trench provides recharge and water quality volume in one location. Infiltrated storm water shall be filtered through soils prior to entering groundwater to remove potential pollutants. Infiltration will only be used where soil conditions and slope stability are suitable.

Practice

- Obtain the runoff coefficient
- Calculate the WQ_v using the unified sizing criteria.
- Compute the maximum allowable depth (d_{max}) of an infiltration trench
- Select the trench depth (d_t) based on d_{max} and depth to water table
- Compute infiltration trench surface area (A_t) by

$$A_t = V_w / (n \mathbf{x} d_t + fT)$$

where

- V_w is the design volume
- n is the porosity, use 0.4
- d_t is the trench depth
- f is the infiltration rate
- T is the effective filling time for most infiltration trenches, use 2 hours.
- The trench will drain an area no larger than five acres.
- All trenches will be designed to fully de-water the entire WQ_v within 48 hours after the storm event.
- At a minimum, 25 percent of the WQ_v must be pretreated prior to entering into the infiltration trench using sump pit, stilling basin, etc.

KEY TERMS

Pervious Surface - Surface area which allow infiltration of water.

Pollutants - Pollutants in the storm water refer to anything that is not water. These items include nutrients such as phosphorus and nitrogen; suspended solids such as sediment; organic carbons and hydrocarbons such as oil and fuel; bacteria; trace metals such as lead; pesticides; and trash and debris.Trash and debris.

Receiving Water - A body of water such as an ocean or lake that ultimately receives all the storm water runoff from a drainage area.

Redevelopment Project - A project that consists of reconstruction or new construction on an existing impervious area exceeding one (1) acre.

Runoff Volume - The volume of water that flows off of a surface during a storm event.

Sheet Flow - Flow that occurs overland in places without defined channels. The flood water spreads out over a large area at a uniform depth.

Special Management Use Area (SMA) - The Revised Ordinances of Honolulu, Chapter 25 states that SMA is, "the land extending inland from the shoreline that was established by the State of Hawaii as requiring a SMA permit. The SMA permit includes development action which either exceeds the valuation of $125,000 or which may have substantial adverse environment or ecological effect, taking into account potential cumulative effects."

Storm Water Runoff - Precipitation which flows over the ground.

Swale - An elongated depression in the land surface that is at least seasonally wet, usually heavily vegetated, and normally without flowing water. Swales discharge storm water into primary drainage channels and may provide some groundwater recharge.

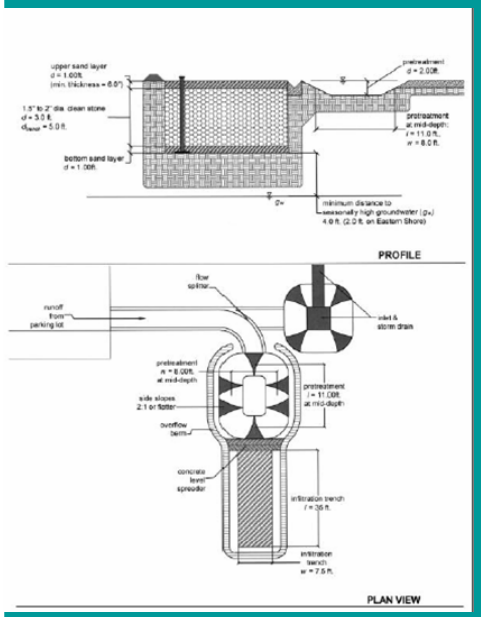
Topographic Map - A type of map depicting a limited set of features but including at the minimum information about elevations or landforms.

Waters of the United States - All waters which are currently used, or where used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide, all interstate waters and wetland, tributaries of these waters, and the territorial seas.

Wetlands—Lands where water saturation is the dominant factor determining the nature of soil development and the types of plants and animal communities living in the surrounding environment. Wetlands are also referred to as bogs, ponds, estuaries, or marches.

INFILTRATION TRENCH

- The bottom of the trench should be separated by at least 4 inches vertically from the seasonally high water table.
- The trench should be located at least 100 feet away from any water well.
- Provide adequate storm water outfalls for the overflow associated with the ten-year design storm event.
- For concentrated flows, the trench will be located "off-line" from the main conveyance system. A flow splitter will be required to divert the water quality volume into the trench.
- After the completion of final grading, the trench should be well aerated and have a highly porous surface texture.
- Trenches may be lined with a 6 to 12 inch layer of filter material, such as coarse sand to help prevent the build-up of impervious deposits. Establish dense vegetation on trench side slopes and floor to prevent erosion and maintain high infiltration rates.
- An observation well shall be installed in every infiltration trench.



- Long-term techniques for infiltration protection are required (three per trench):
  - ◊ Grass channel
  - ◊ Grass filter strip (minimum 20 feet and only if sheet flow is established and maintained)
  - ◊ Bottom sand layer
  - ◊ Upper sand layer (6 inches minimum) with filter fabric at sand/gravel interface
  - ◊ Washed bank run gravel used as aggregate

Introduction

Improvement and development at Honolulu International Airport (HNL) directly influences the water quality of the surrounding waters, including Keehi Lagoon and Mamala Bay. Buildings, pavement, and other impervious surfaces reduce the ability of the ground to absorb rainfall. Additionally, any pollutants left on the impervious areas, such as vehicle oil leaks, are washed away during storm events. These pollutants ultimately end up in Keehi Lagoon or Mamala Bay either through sheet flow or HNL's Small Municipal Separate Storm Sewer System (MS4).

Common pollutants from the airport development include suspended solids and nutrients such as phosphorus and nitrogen from excess sediment washed into the water. Additionally, petroleum products such as oil and jet fuel can enter the storm water from aircraft or vehicle leaks and spills. Other pollutants include trace metals from batteries or exposed scrap metals and debris from uncovered trash bins or littering. All of these pollutants effect the health of the coral reefs in the area as well as the health of recreational users of those waters. Both Keehi Lagoon and Mamala Bay are listed on the Clean Water Act (CWA) 303 (d) list of impaired waters.

Retention Basin

Description

A retention basin is a surface depression designed to capture the storm water runoff from the surrounding drainage area for disposal through evaporation and percolation. The primary functions of retention basins are to remove pollutants from storm water runoff where soil conditions are suitable, and to recharge or replenish groundwater. In addition, retention basins can significantly reduce total annual surface runoff volume, which can reduce stream bank erosion and other adverse impacts to stream habitats from storm water runoff.

Practice

- Determine the WQ_v using the unified sizing criteria.
- Obtain the runoff coefficient.
- Protect natural infiltration rate during construction through proper scheduling and techniques.
- Use lightweight equipment and construction procedures that minimize compaction.
- Inspect annually and following significant storm events.
- Debris and sediment accumulations are to be removed from the retention basin whenever these materials prevent proper functioning of the basin. Generally, this occurs when the sediment layer exceeds 12 inches.
- Retention basin floors shall be tilled as needed to restore the infiltration capacity and to control weed growth on the basin floor. Tilling shall be accomplished using rotary tillers or disc harrows.

Another common issue associated with airport development is the increased storm water runoff velocity since the water cannot infiltrate into the ground. The increase in velocity can potentially cause flooding and soil erosion both at the airport as well as the surrounding areas.

Therefore, post-construction BMPs should be implemented in current and future construction projects, retrofitted for existing structures, and impermeable areas to limit the environmental impact from airport development. The goals of these specific BMPs are to reduce the amount of storm water runoff leaving the airport, control pollutants, and treat the storm water runoff at the site.

Post-construction BMPs are a requirement of both the State of Hawaii Department of Health (DOH) Notice of General Permit Coverage (NGPC) for construction projects and HNL's National Pollutant Discharge Elimination System (NPDES) Permit No HI S00005. The program is described in further detail within HNL's Storm Water Management Program Plan (SWMPP).

BIORETENTION - RAIN GARDEN

Description

Bioretention combines open space with storm water treatment in vegetated areas where runoff is directed through vegetation and soils for filtration. It captures and temporarily stores the water quality volume and passes it through a filter bed of sand, organic matter, soil, or other media. Filtered runoff may be collected and returned to the conveyance system or allowed to partially infiltrate into the soil.

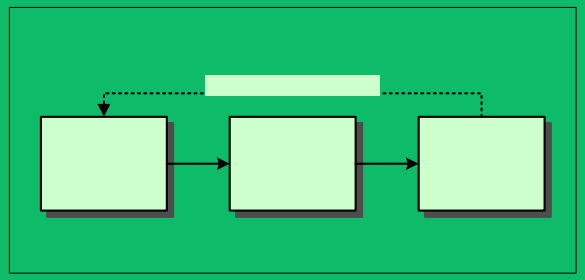
Practice

- Obtain the runoff coefficient.
- Determine the WQ_v and Af using the unified sizing criteria.
- A porosity value "n" (n=Vv/Vt) of 0.40 should be used in the design of stone reservoirs for infiltration methods.
- Treatment components shall include
  - ◊ 2 ½ to 4 foot deep planting soil bed;
  - ◊ Surface mulch layer; and
  - ◊ 12 inches deep surface ponding area.

Post-Construction BMP Design Criteria

New development and redevelopment construction projects that result in a land disturbance of one (1) acre or more and construction projects that have potential to discharge pollutants to HNL's Small MS4 should be reviewed for implementation of post-construction BMPs. Projects that return area to pre-development runoff conditions and projects that do not have any impacts on storm water are exempt from post-construction BMP implementation.

It is important to consider post-construction BMPs throughout every phase of a construction project, including planning, conceptual engineering, and final design. Early consideration of post-construction BMPs will help identify sufficient rights-of-way needs and costs, potential community impacts, and design conflict. Therefore, post-construction BMPs should be considered throughout the life cycle of a project.

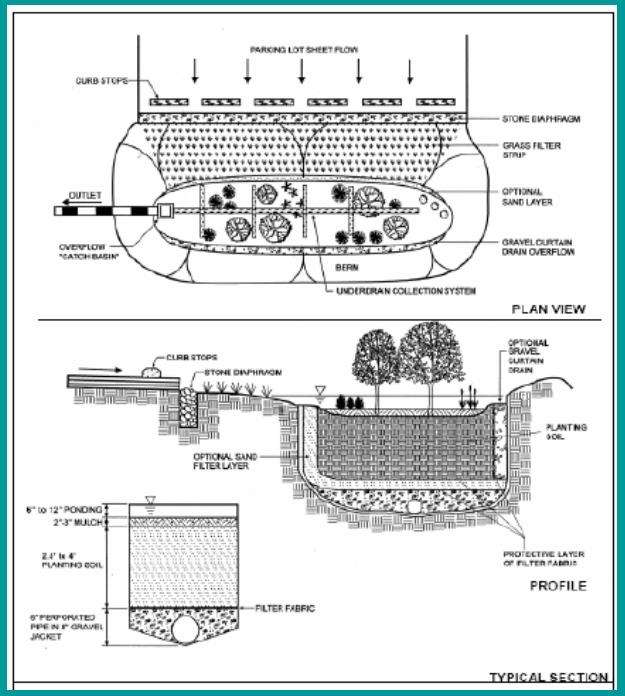


The basic steps in the storm water management plan process are:

- Assess site and watershed conditions;
- Understand hydrologic conditions of concern;
- Evaluate pollutants of concern;
- Identify candidate BMPs;
- Determine BMP size and capacity; and
- Develop a plan for BMP maintenance.

Bioretention - Rain Garden

- The ponding depth should be less than 6 inches or less with a mulch layer of 2 to 3 inches.
- Overflow for the ten-year storm event shall be provided to a non-erosive outlet point and non-erosive velocities shall result.
- A flow regulator shall be provided to divert the storm water runoff to the filtering practice.
- The filters shall have a 6 inch perforated underground drain pipe in a gravel layer.
- A permeable filter fabric shall be places between the gravel layer and the filter media.
- Landscaping is critical to the function and performance of the bioretention areas. A landscaping plan shall be provided for these areas including dense and vigorous vegetation.



Post-construction BMPs can be viewed through three different objectives to improve water quality:

1. **Control the Source of Pollutants.** This method prevents contaminants from entering the storm water system initially.
2. **Reduce Runoff.** This method detains the storm water on-site so that it can infiltrate into the ground or evaporate; thereby reducing the contaminants that leave the site.
3. **Treat Polluted Runoff.** This methods take into consideration that certain contaminants must be generated during construction, redevelopment, or facility activities. Therefore, the storm water runoff is treated to remove as much of the contaminant as possible before it enters the receiving water.

Post-Construction BMPs should be designed by a licensed engineer with support from project planners and landscape architects. In order to design the BMPs, the storm water flow must be identified, specifically its exit points at the site. Once the study points are identified, the volumetric storage requirements should be estimated. A post-construction BMP design concept report should be generated that includes the following:

- Description of the project area;
- Description of the environmental resources;
- Description of the outfalls with condition report;
- Regulatory requirements;
- Proposed BMP location;
- Proposed BMP concept descriptions including assumptions, type, and treatment;
- Surface area and volume calculations;
- Topographic map showing BMP footprints;
- Preliminary construction cost for the proposed BMPs; and
- Appendices which consist of exiting and proposed drainage area maps, photos, and computations.

SAND FILTERS

Description

Sand filters are usually designed as two-chambered storm water practices; the first is a settling chamber, and the second is a filter bed filled with sand or another filtering media. As storm water flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as the storm water flows through the filtering medium. There are several modifications of the basic sand filter design, including the surface sand filter, underground sand filter, perimeter sand filter, organic media filter, and Multi-Chamber Treatment Train. All of these filtering practices operate on the same basic principle. Modifications to the traditional surface sand filter were made primarily to fit sand filters into more challenging design sites (e.g., underground and perimeter filters) or to improve pollutant removal (e.g., organic media filter).

Practice

- Determine the WQ_v using the unified sizing criteria. Typical water quality volumes include the runoff from a 1-inch storm event or ½ inch of runoff over the entire drainage area.
- Obtain the runoff coefficient.
- Calculate the required filter bed area (Af).
- Sand filters are best applied on small sites up to 10 acres and up to 2 acres for perimeter or underground sand filters.
- They require an elevation drop, or head (about 5 to 8 feet), to allow flow through the system.
- Provide at least 2 feet of separation between the bottom of the filter and the seasonally high ground water table.
- The filter bed should have a minimum depth of 12 inches.

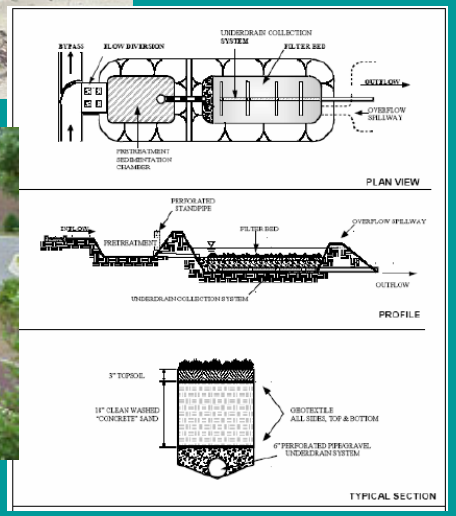
Source Control Best Management Practices

These BMPs work to stabilize the soil both during and following construction activities; thereby preventing sediment from impacting the storm water system or receiving water.

SAND FILTERS

- Provide at least 25 percent of the WQ_v in a dry or wet sedimentation chamber as pretreatment to the filter system.
- Provide at least 75 percent of the water quality volume in the practice including both the sand chamber and the sediment chamber.
- The sand filters shall have a 6 inch perforated underground drain pipe in a gravel layer.
- A permeable filter fabric shall be places between the gravel layer and the filter media.
- Use a flow splitter, which is a structure that bypasses larger flows to the storm drain system or to a stabilized channel during larger storms.

Surface Sand Filter



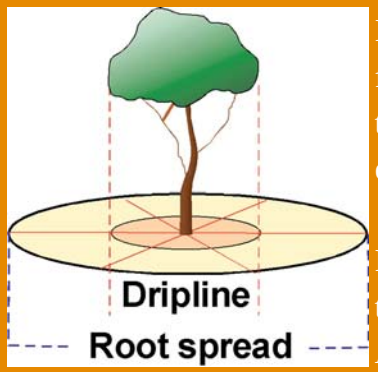
Preservation of Existing Vegetation BMP

Description

Preservation of existing vegetation involves protecting desirable plants and trees in any area subject to land-disturbing activities. The primary function of existing vegetation preservation is to provide an effective form of soil stabilization control, as well as watershed protection, landscape beautification, dust control, pollution control, noise reduction, and shade.

Planning

Select sensitive areas, such as steep slopes, to preserve vegetation before the site is disturbed. Select vegetation based on health of the plant, aesthetics, wildlife benefits, adaptability, and life expectancy. All the vegetation that is to be kept on-site should be marked and protected in the construction site.

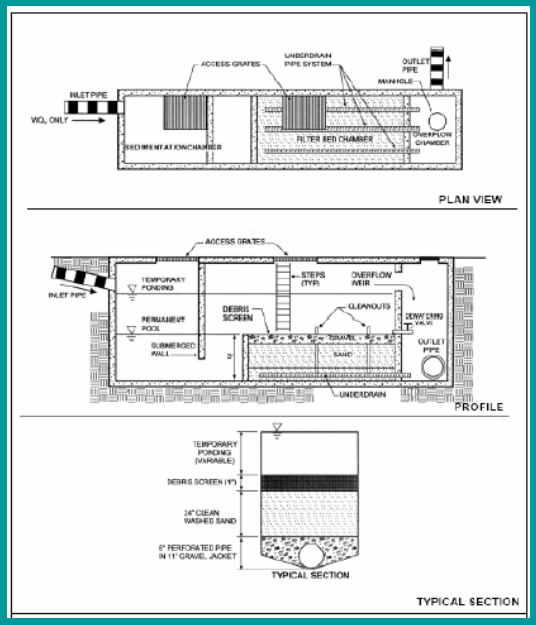


If trees are to be retained, mark off a 5 foot area around the drip line to ensure that the roots are not damaged by equipment.

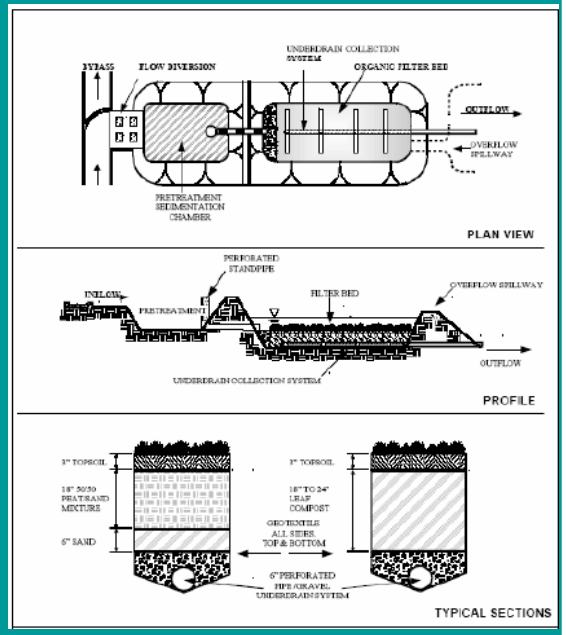
Plans should also include details about the maintenance required for the plants. Any compacted soil around the plants should be aerated. Any damage to the tree or plant should be repaired by consulting with an arborist. Trees should be fertilized in late fall or early spring.

Sand Filters

Underground Sand Filter



Organic Sand Filter



PERMANENT SEEDING AND PLANTING BMP

Description

Permanent seeding and planting is the process of establishing a perennial vegetative cover on areas that have been disturbed by construction or maintenance activities or are otherwise subject to erosion. Permanent vegetation shall be self-sustaining, need low maintenance, and be compatible with the surrounding environment.

The goal of the seeding is to reduce erosion by slowing runoff velocities, protect soil from raindrop impact, enhance infiltration and transpiration, trap sediment and other particulates, improve long-term aesthetics, and provide wildlife habitat.

Planning

Select the planting site by identifying the soil type and condition, site topography, climate and season, types of vegetation suited to the site, maintenance concerns, and aesthetic considerations.

Practice

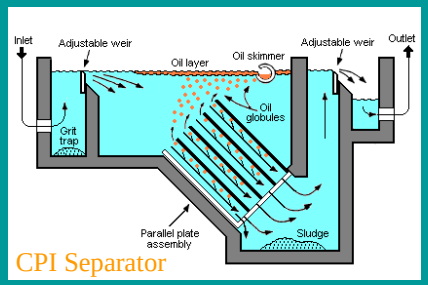
- Roughen the slope or area to be seeded by plowing, disking, or raking to a depth of 6 inches.
- Plant the seed using broadcast seeding, seed drilling, or hydraulic application of seed.
- Mulch, fertilize, and irrigate the seed as necessary.
- Cutting or mowing grasses will encourage the establishment and spread of the grass.
- All seeded areas should be inspected to ensure that the vegetation is growing.

Note that Hawaii Department of Agriculture requires that all seed bags be sealed and marked with species, purity, percent germination, dealer's guarantee, dates of test, and the words "Pure Live Seed (PLS)."

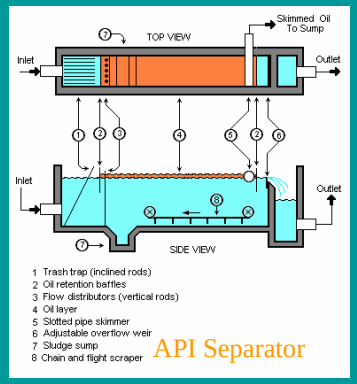
OIL/GRIT SEPARATOR

Description

Oil/grit separators are permanent treatment control devices designed to remove contaminants. The conventional separator, known as the American Petroleum Institute (API) separator, and the coalescing plate interceptor (CPI) are two commonly used oil/grit separators. The primary function of oil/grit separators is to specifically remove petroleum compounds, other floatable debris, and settleable solids. Conventional separators are capable of removing oil droplets with diameters greater than 150 microns. CPI separators are used when droplets smaller than 150 microns must be removed.



CPI Separator



API Separator

Practice

- Determine the size of separators based on rate of runoff, rise-rate velocity of the oil droplets, and the settling rate of solids to be removed.
- Oil/grit separators shall be sized to treat the first flush of runoff; however, larger storms may be diverted around the separator.
- Determine type of separator, CPI or conventional. CPI separator contains closely spaced plates that enhance the removal efficiency.
- Oil/grit separators shall be inspected at least monthly and following significant storm events.

MULCHING BMP

Description

Mulching is the process of applying loose bulk materials to the soil surface as a permanent or temporary cover. Common types of mulch are: green material, hydraulic matrices, hydraulic mulches made from recycled paper or wood fiber, stone and aggregate, vegetable fibers (hay or straw), and wood/bark chips. The primary function of mulching is to reduce erosion by protecting bare soil from rainfall impact, increasing infiltration, and reducing runoff. Mulches have varying limitations so please review the full BMP in the HNL SWMPP before application. Mulches are also generally used to compliment seeding and vegetation establishment techniques.

Practice for Hay Mulching

- Apply seed and fertilizer to bare soil.
- Apply loose hay or straw over the top of seed/fertilizer at a rate of 2 tons per acre either by machine or by hand distribution.
- The mulch must be evenly distributed on the soil surface so that 80 to 90 percent of the ground is covered.
- Maximum fiber length shall be maintained and average fiber length shall be greater than 6 inches.
- Anchor the mulch in place by using a tackifier, netting, or "punch" it into the soil mechanically.
- "Punching" straw of hay into the soil can be accomplished with spade or shovel on small areas. On steep slopes, use plastic netting or jute held in place with wire staples, geotextile pins, or wooden stakes.

CONTINUOUS DEFLECTIVE SEPARATION (CDS)

Description

Continuous Deflective Separation (CDS) technologies direct solid pollutants into the lower catchment chamber and the floatables to the surface of the upper chamber using a non-mechanical, non-blocking screen technology. The system utilizes the natural motion of water to separate and trap sediments by direct infiltration. As storm water flows through the system, a very fine screen deflects the pollutants, which are captured in a litter sump in the center of the system.

Practice

- Determine the WQ_v using the sizing criteria.
- Processing capabilities vary from 3 to 300 cubic feet per second.
- Conduct detailed hydraulic analysis before installation to ensure optimum solids separation.
- Aggressive maintenance is required to reduce the risk of re-suspension of sediment during large storm events. Manholes should be included for each chamber for cleaning access.
- Document the amount of material removed from each chamber during the cleaning process.
- Disposal of waste should be done according to material contents and disposal requirements.

Geotextiles, Mats, and Erosion Control Blankets BMP

Description

Matting made of natural or synthetic material is used to temporarily or permanently stabilize soil. These products are to be considered at any sites where disturbed soils must be stabilized.

Site Preparation

- Grade and shape the area of installation
- Remove all rocks, clods, or other obstruction
- Prepare seedbed by loosening 2 to 3 inches of topsoil.
- Fertilize and seed the area
- Anchor the mat into the ground with U-shaped wire staples, metal geotextile stake pins, or triangular wooden stakes.

Installation

- Begin at the top of the slope and anchor the mat.
- Unroll the blanket or mat down the slope in the direction of water flow.
- Overlap the edges of adjacent parallel rolls 2 to 3 inches and staple every 3 feet.
- When blankets must be spliced create a 6-inch overlap.
- Lay blanket loosely and maintain direct contact with the soil.
- There are additional instructions for installing in a channel.

Inspection

- All blankets must be inspected after installation and significant rainstorms.
- Replace if failures or washouts occur.

Green Roofs

Description

A green roof, or rooftop garden, is a vegetative layer grown on top of an elevated impervious surface. Green roofs provide shade and reduce the heat within the structure through evapotranspiration, which reduces the temperatures of the roof surface and the surrounding air. In addition to mitigating urban heat islands, green roofs provide enhanced storm water management and water quality treatment. They can reduce and slow storm water runoff from impervious areas. The plants and growing medium of a green roof, in the same manner as other natural surfaces and vegetation, absorb water that would otherwise become runoff. The amount of rainfall retained by a green roof will depend primarily on the depth of the growing medium and may also be affected by the roof slope.

Green roofs can be installed on a wide range of buildings, from industrial facilities to private residences. They can be as simple as a 2-inch covering of hardy groundcover generally termed an “extensive” system, or as complex as a fully accessible park complete with trees, called an “intensive” system. Steeper roofs may retain less storm water than an equivalent, flatter roof.

Extensive Green Roofs

- Simpler and lighter weight.
- Plant selections typically include succulent, hardy varieties that do not require shade as well as other vegetation generally suitable for the environment in Hawaii.

Vegetated Buffer Strips and Channels BMP

Description

Vegetative buffer strips and channels can be used to reduce the discharge of pollutants to the storm drain system or to watercourses from a new development or redevelopment. The vegetated surfaces are used to protect soils from erosion and to slow the velocity of runoff to allow the removal of sediment through filtering and settling. A vegetated buffer strip is a strip of land parallel to and adjacent to the edge of the contributing surface. It can be created with either new vegetation as part of a development project or a strip of existing vegetation that is left undisturbed during adjacent development.

Practice

- Remove all weeds and debris from the area;
- Plant as soon as possible after the area has been graded;
- Select a seed mixture appropriate to the site conditions (dense grass are most effective in slowing storm water velocity and removing pollutants);
- Water and fertilize the vegetation as needed;
- Avoid using the vegetated buffer strip for vehicular traffic;
- Inspect the plantings weekly and after significant storm events until they are established;
- Maintenance consists of mowing, weeding, and ensure the plants are adequately watered; and
- Repair any eroded or damaged areas.

Green Roofs

- Plants adapted to extreme climates often make good choices and may not require permanent irrigation systems.
- The concept is to design a rugged green roof that needs little maintenance or human intervention once it is established.
- Green roofs are ideal for retrofitting an existing structure.
- Green roofs have been grown on roofs with slopes of 30° or more, which would equal a ratio of rise to run of 7:12 or greater.
- Overall, because of their light weight, extensive green roofs will require the least amount of added structural support.

Intensive Green Roofs

- An intensive green roof is similar to a conventional garden, or park, with almost no limit on the type of available plants, including large trees and shrubs.
- Buildings often install these roofs to save energy and provide a garden environment for the building occupants recreation.
- Compared to extensive green roofs, intensive green roofs are heavier and require a higher initial investment and more maintenance.
- They generally require more structural support to accommodate the weight of the additional growing medium and public use.
- Intensive systems also need to employ irrigation.

Runoff Reduction Best Management Practices

These BMPs work to reduce the amount of runoff exiting the property; thereby reducing the discharge of potential pollutants that may be present in the storm water at the site.

Alternative Wetlands

Description

The Federal Aviation Administration (FAA) requires that wildlife, specifically birds be limited within the airport due to the safety threat they pose to the aircraft. Therefore, it is not recommended that large wetland areas be developed within the airport limits, since they will likely draw local bird populations. However, alternative wetlands can be considered.

Floating Wetlands

The floating wetland is constructed of vegetation grown on a raft. The raft is placed in a polluted body of water such as a canal and the plants draw pollutants out of the water. Depending on the type of plant, the pollutant will either be stored in the plant or metabolized. When installing the BMP, the type of plant used must be considered as well as the plant disposal method.

Modular Wetlands

Smaller wetlands can be created adjacent to storm drains. These wetlands are usually accompanied by a 4-Stage Treatment Train. These can be used to treat the storm water in the MS4 as well as to reduce the flow rate. Hardy varieties of plants should be chosen that can survive during dry weather periods.

Earth Dikes, Drainage Swales, and Lined Ditches

Description

Earth dikes, drainage swales, and lined ditches are structures that intercept, divert, and convey surface runoff. The primary functions of such structures are to prevent erosion and to reduce pollutant loading conveyed to receiving waters.

Practice

- Select the design flow and safety factor based on evaluation of the risks associated with erosion and over topping, flow backups, or wash out of the structure.
- Examine the site for run-on from off-site sources.
- Select a flow velocity limit based on site-specific soil types and drainage flow patterns.
- Establish a maximum flow velocity for using earth dikes and swales, above which a lined ditch must be used.
- Design an emergency overflow section or bypass area for larger storms that exceed the design storm.
- Install and utilize permanent dikes, swales, and ditches early in the construction process.
- Conveyances must be lined when velocities exceed allowable limits for the soil type. Consider use of riprap, engineering fabric, vegetation, or concrete.
- If sediment-laden water is expected in those conveyances, discharge flows from the conveyance into a sediment-trapping device.
- Temporary conveyances are to be completely removed as soon as the surrounding drainage area has been stabilized, or at the completion of construction.
- Inspect conveyances at least once every two years.

Permit Requirements

Resource or Activity	Agency	Permit or Approval[1]
Construction site that disturbs more than one acre of land.	Hawaii Department of Health (HDOH), Clean Water Branch (CWB)	NPDES Form C
Dewatering	HDOH CWB	NPDES Form G
Construction activity which will generate a discharge of a pollutant from a point source into a navigable water[2].	HDOH CWB	401 Water Quality Certification
Construction within a navigable water (including dredging).	U.S. Army Corps of Engineers (ACOE)	Rivers and Harbors Section 10; Coastal Zone Management
Discharging dredged or fill material into a navigable water.	ACOE	CWA 404 permit
Construction within Special Management Area (SMA) (Lagoon Drive and the southern portion of HNL)	City and County of Honolulu Department of Planning and Permitting (DPP)	SMA permit
Grading	DPP[3]	Grading permit
Building a structure within airport airspace	Federal Aviation Administration	Federal Aviation Regulations, Part 77
Excavation	Hawaii One Call Center	Marks all underground utility lines

[1]This is not an exhaustive list of permits and additional permits may be necessary for an individual project.
[2]Navigable water is defined in Hawaii Administrative Rules 11-54-9.1.
[3]The DPP may require additional building permits based on the project.

Slope Drains and Subsurface Drains

Description

A slope or subsurface drain is a pipe used to intercept and direct surface runoff or ground water into a stabilized watercourse, trapping device or other stabilized area. The primary function of a slope drain is to convey runoff down cut or fill slopes. A typical slope drain schematic is attached. The primary function of subsurface drains is to drain excessive soil saturation in sloping areas.

Practice

- Drainage area maximum is 10 acres.
- Maximum slope is 2:1 (H:V).
- Use interceptor dikes to direct surface runoff into a slope drain.
- Use a standard flared end section or headwall at the entrance to pipe slope drains larger than 12 inches to improve inlet hydraulics.
- Protect area around inlet with lining such as vegetation, filter cloth, etc.
- Place drainpipes on or bury them underneath the sloped surface.
- Securely anchor and stabilize pipe and appurtenances into soil.
- Direct flows to a detention basin if the slope drain has the potential to convey sediment-laden water.
- Protect outlets with riprap or other energy dissipation method.
- Inspect slope and subsurface drains annually during the rainy season. Follow routine inspection procedures for inlet thereafter.

National Pollutant Discharge Elimination System (NDPES) Notice of General Permit Coverage (NGPC) for Construction Activities

Applicability

Any construction project that disturbs one (1) acre or more of total land area, which includes activities that disturb less than one acre of total land area if they are a part of a larger common plan of development that will ultimately disturb one acre or more of total land area. Regulated under HAR §11-55 Appendix C.

Agency and Fees

The Notice of Intent (NOI) Form C will be filed with the Hawaii Department of Health (HDOH), Clean Water Branch (CWB) with the $500 filing fee.

NOI Requirements

The applicant must complete the form located at: http://hawaii.gov/health/environmental/water/cleanwater/forms/genl-index.html.

A construction best management practices (BMP) plan must be attached which includes the following: site characterization report; construction timetable and description; area of site and disturbed area; quantity of storm water runoff; soils to be used; site map; construction management techniques; county-approved erosion and sediment control plan; post-construction BMPs; and a description of non-storm water discharges.

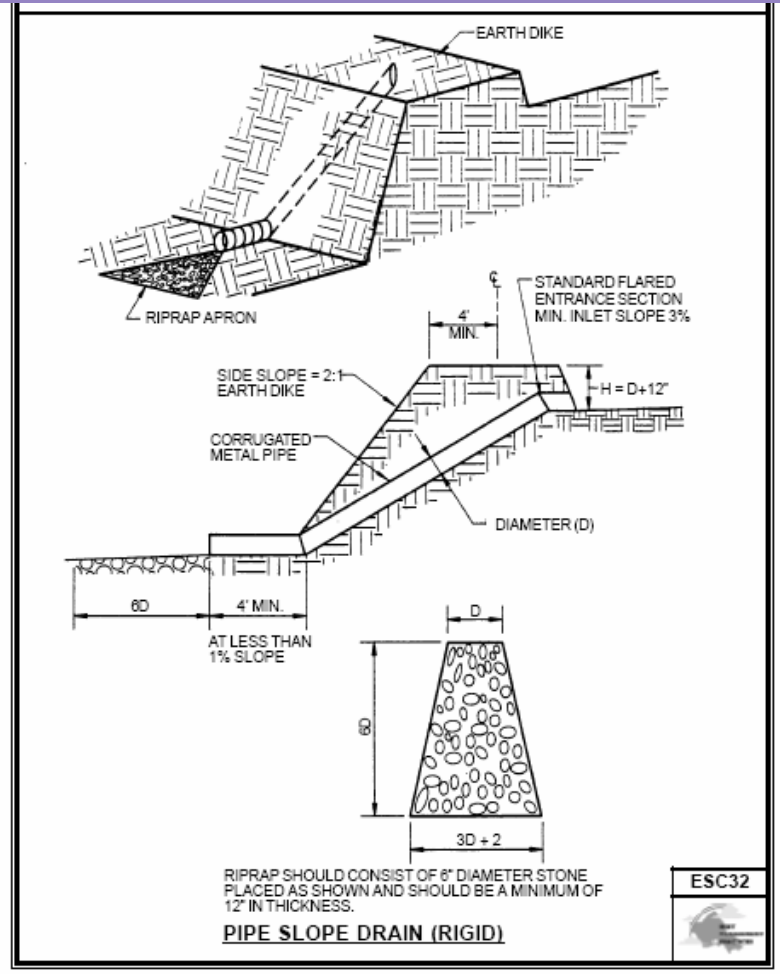
Permit Conditions

- The activity must not contribute to a violation of water quality
- The applicant must inspect the state waters and implemented BMPs
- The applicant must report any pollutant source to the HDOH

Timeline

- The applicant must submit the NOI Form C 30 days prior to the start of construction activities.
- The permit is effective 10 days after filing with the lieutenant governor.
- The applicant must notify the HDOH one week prior to the start of construction.
- The permit will expire 5 years after the effective date.

Slope Drains and Subsurface Drains



National Pollutant Discharge Elimination System (NDPES) Notice of General Permit Coverage (NGPC) for Dewatering Activities

Applicability
Due to the high water table within the Honolulu International Airport (HNL), dewatering activities may be required within a construction project. These activities are regulated under HAR §11-55 Appendix G.

Agency and Fees
The Notice of Intent (NOI) Form G will be filed with the Hawaii Department of Health (HDOH), Clean Water Branch (CWB) with the $500 filing fee.

NOI Requirements
The applicant must complete the form located at: http://hawaii.gov/health/environmental/water/cleanwater/forms/genl-index.html.

The NOI form requires a site characterization report; project description and timeline; analysis of source water quality; a dewatering plan; a dewatering maintenance plan; and construction pollution prevention. Additionally, if the site is over one acre of land, a county erosion and sediment control plan is required.

Permit Conditions
The applicant must monitor the discharge and submit a discharge monitoring report (DMR) to the HDOH. If the discharge is intermittent, it must be sampled once per discharge. If the discharge is continuous, the water must be sampled at least once per month. If the sampling reveals that constituent levels are not in compliance with the levels set forth in the dewatering plan, the HDOH must be notified. A written report will be sent within five days or an oral report will be made within 24 hours.

Timeline
- The applicant must submit the NOI Form G 30 days prior to the start of construction activities.
- The permit is effective 10 days after filing with the lieutenant governor.
- The applicant must notify the HDOH one week prior to the start of construction.
- The permit will expire 5 years after the effective date.

Top and Toe of Slope Diversion Ditches/Berms

Description

Top and toe of slope diversion ditches/berms are devices used to intercept and direct surface runoff to a slope drain, stabilized watercourse, or stabilized area. The primary function of top and toe of slope diversion ditches/berms is to minimize sheet flow over slope surfaces and reduce sedimentation by conveying collected runoff to a protected drainage system.

Practice

- Select design flow and safety factors based on evaluation of risks associated with erosion and overtopping, flow backups, or washout of the structure.

- Line or stabilize ditches where high flow velocities will occur.
- At top of slope, direct flow to slope drains.
- When installing diversion ditches and berms protect outlets from erosion.
- Use planned permanent ditches/berms early in the construction phase when practicable.
- Inspect permanent measures prior to the rainy season, after rainfall events exceeding their designed storm intensity during the rainy season.
- Inspect ditches/berms for washouts. Replace lost riprap, damaged linings or soil stabilizers as needed.
- Inspect structures and their inlets and outlets for accumulation of debris and sediment. Remove debris and sediment as needed.

Section 401 Water Quality Certification

Applicability

Any activity, including construction, which may result in any discharge to navigable waters must be regulated by the Section 401 Water Quality Certification (WQC) under HAR §11-54-9.1.

Agency and Fees

The Section 401 WQC form will be filed with the Hawaii Department of Health (HDOH), Clean Water Branch (CWB) with the $1,000 filing fee.

Requirements

The applicant must complete the form located at: http://healthuser.hawaii.gov/health/environmental/water/cleanwater/forms/wqc-index.html.

The Section 401 WQC form will require information about the owner, contractor, site, and receiving water. The applicant must describe the project, the project schedule, and the existing environment condition. The applicant must attached a site characterization, monitoring and assessment plan, and mitigation/compensation plan. In addition, the applicant must describe the source and duration of the discharge as well as the description of any dredged materials.

Permit Conditions

The applicant must monitor the receiving water body before, during, and after construction activities. The HDOH has provided a matrix of the constituents that must be sampled along with frequency and duration at the above website.

Timeline

- After a completed Section 401 WQC has been filed, the HDOH director has one year from that date to act on the request.
- The director may provide the opportunity for a public hearing or for public comments (30 days).
- The permit will expire 2 years after the effective date.

Outlet Protection / Velocity Dissipation Devices

Description

Outlet protection/velocity dissipation devices are physical mechanisms placed at the outlets of pipes and channels. The primary function of such devices is to reduce the velocity and/or energy of existing water, preventing scour and minimizing the potential for downstream erosion.

Practice

- Apron length shall be based on outlet flow rate and tail-water level.
- Align apron with receiving stream and keep the apron straight throughout its length. If a curve is needed to fit site conditions, place it in the upper section of the apron.
- If the size of apron riprap is 12 inches or longer, protect the underlying filter fabric with 4 inches minimum of gravel blanket.
- Provide additional protection where flow re-concentration and high flow velocities leaving the apron can occur, such as at the top of cut slopes or on slopes steeper than 10 percent.
- Establish a routine inspection schedule for permanent measures so that all structures are inspected at least once every three years.

United States Army Corps of Engineer Permits

Rivers and Harbors Act 1899 §10
Section 10 of the Rivers and Harbors Act of 1899 requires approval prior to the accomplishment of any work in or over navigable waters of the United States, or which affects the course, location, condition or capacity of such waters. Typical activities requiring Section 10 permits include, dredging and excavation, artificial reefs, and construction of piers, ramps, floats, or pipeline.

Clean Water Act §404
Section 404 of the Clean Water Act requires approval prior to discharging dredged or fill material into the waters of the United States.

Coastal Zone Management Act §307
Section 307 of the Coastal Zone Management Act of 1972, as amended (16 U.S.C. 1458(c)), requires the applicant to certify that the project is in compliance with an approved State Coastal Zone Management Program (CZM) and that the State concurs with the applicants certification prior to the issuance of a Corps permit. Information on the State CZM program can be found at http://hawaii.gov/dbedt/czm/index.php.

All Permit Requirements
All of the above permits are filed for using the standard form located at http://www.poh.usace.army.mil/ec-r/EC-R.htm. In addition, the applicant must provide construction drawings, location maps, and a description of the activity. For dredging projects, a description of the type, composition, quantity, and disposal methods for the material must be provided.

Fees
The U.S. Army Corps of Engineer (USACE) charges $100 for projects with industrial/commercial use and $10 for projects that involve non-commercial work. If multiple permits are required, additional fees are not charged.

Timeline
Prior to applying for the permit, the applicant can schedule a pre-application meeting with the USACE to determine which permits are required. After the application is submitted, the engineer will have 15 days to evaluate the application. Then the public will be allowed to comment for a 30 day period. Following the public comment period, the engineer will have 30 days to make a final decision on the application. Once the permit is issued, it will not expire for 10 years or until the project is completed.

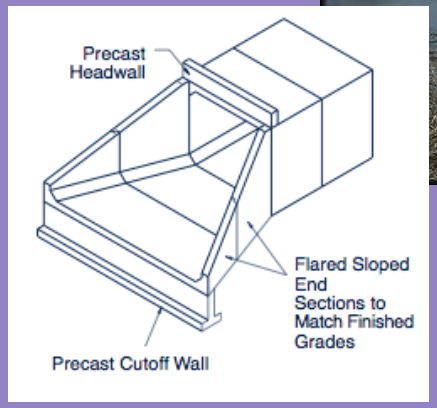
Flared Culvert End Sections

Description

Flared culvert end sections are physical devices at the inlets and outlets of pipes and channels. The primary function of flared culvert end sections is to help prevent scour and minimize erosion at inlets and outlets. Such end sections can also improve the hydraulic operation and retain the embankment near pipe conveyances. A general design concept for a flared end section is detailed below.

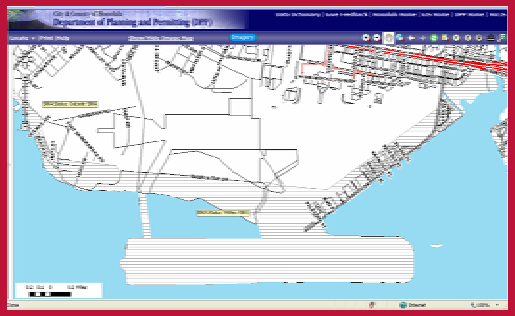
Practice

- Construct at zero grade when possible.
- Use in conjunction with other outlet protection.
- At inlets, protect the transition into a flared end section to prevent scouring.
- Inspected flared end sections before the rainy season.



Special Management Area Use Permit

Applicability



There are two permits which apply to the special management use area (SMA); the SMA - minor permit covers developments that have a value less than $125,000 with no adverse environmental effects and the SMA-major permit covers any development, structure, or activity within the SMA as defined by Chapter 25 of the Revised Ordinances of Honolulu. At the Honolulu International Airport, the SMA includes the south ramp and reef runway areas (shaded areas of figure 1).

Agency and Fees

The City and County of Honolulu Department of Planning and Permitting (DPP) issues both the SMA - major permit as well as the SMA - minor permit. The SMA - major permit has varying fees; for agriculture, aquaculture, or outdoor recreation the fee is $300 and for all other developments the fee is $600 plus an additional $300 per acre up to a maximum of $10,000. The SMA - minor permit has a fee of $100.

Requirements

The SMA - major permit is a two phase process. The first phase involves preparing an Environmental Assessment (EA) or Environmental Impact Statement (EIS) for the project. The second phase involves the processing of the permit application and includes a public hearing.

The SMA - minor permit involves completing the application form and attaching a project description as well as plans and drawings. The application form for both permits can be found at: http://www.honoluludpp.org/download/permits/permitlistings.asp?p_TypeID=2.

SMA - Major Permit Timeline

- A pre-application meeting with DPP is recommended to determine SMA requirements.
- The DPP will hold a public hearing 60 days after acceptance of application.
- 10 days after the public hearing, the findings are transmitted to the City Council.
- The City Council must take action within 60 days after the close of the public hearing.

Slope Roughening / Terracing / Rounding

Description

Roughening, terracing and rounding are techniques used for creating down slope unevenness on bare soil. This is done by constructing furrows or intermediate benches running across a slope or by the use of construction equipment to track the soil surface. The primary function of surface roughening or terracing is to reduce erosion potential by decreasing runoff velocities, reducing the length of sheet flow, trapping sediment, and increasing infiltration of water into the soil.

Terracing Practices

- Terraces or benches are to be considered in design of slopes 4:1 (H:V) when slope heights exceed 30 feet. For highly erosive soils, and steeper slopes, slope heights as low as 15 feet are considered.
- Runoff from terraces and benches are to be directed to lined diversion ditches, installed where the terrace meets the slope.
- All slopes shall be rounded and then seeded and mulched to obtain seed germination and growth.
- Routinely inspect the terraces to ensure that they have not been eroded.

See BMP in the HNL SWMPP Section D for addition methods for slope roughening and rounding.

City and County of Honolulu Department of Planning and Permitting (DPP) Building Permits

Applicability

The DPP requires permits for a variety of construction activities. A complete list with the associated application form can be found at http://www.honoluludpp.org/download/permits/. For example, projects with the Honolulu International Airport may require grading operations and therefore a grading permit. A grading permit is required for any project that changes the drainage pattern, exceeds 50 cubic yards (cy) of cut or fill, or exceeds 3 feet in vertical height at its deepest point.

Agency and Fees

The applicant should contact the DPP to determine specific fees for individual projects. As an example, grading permit fees depend upon the amount of cut or fill material. If there is less than 1,000 cy, the fee is $45 for each 100 cy; from 1,001 to 10,000 cy of cut or fill, the fee is $450 for the first 1,000 cy plus $45 for each additional 1,000 cy; and if the cut or fill is more than 10,001 cy, the fee will be $855 for the first 10,000 cy plus $27 for each additional 1,000 cy.

Grading Permit Requirements

The DPP issues the grading permit as required by Chapter 14 of the Revised Ordinances of Honolulu. The application requires a grading plan that includes project information, slope calculations, existing and new drainage patterns, quantity and description of cut or fill material, disposal plans, and best management practices (BMPs). The grading permit application has additional requirements based on the nature of the project.

Drainage Plan and Erosion Control Plan and Procedures may be required if the project covers more than 7,500 square feet or the cut or fill exceeds 7.5 feet in height.

Engineering Slope Hazard Report may be required if the cut or fill is greater than 15 feet in height and has a grade steeper than 40 percent.

Engineer's Soils Report:

- The cut or fill exceeds 7.5 feet in height;
- The proposed grading is on land with existing slopes exceeding 15%;
- Any fill is to be placed over a swamp, pond, lake, wetland, or waterway;
- The fill material will be highly plastic clay; or
- The fill is to be used to support foundations for buildings.

Level Spreader

Description

A level spreader is an outlet for dikes and diversions that disperses the runoff discharged from the slope. Its primary function is to help reduce erosion by dispersing small volumes of concentrated runoff as sheet flow. A level spreader can be the top of a channel, an earthen berm, or a rigid weir-like structure that distributes flow fairly evenly across its length at non-erosive velocities onto stabilized areas.

Practice

- Runoff containing high sediment loads must be treated device before being released to a level spreader.
- Use a rigid outlet lip design for high flow volume.
- The outlet area below the level spreader must be uniform and well vegetated having a slope of 10% or less.
- Do not allow discharge flow to re-concentrate below the level spreader outlet.
- Vehicles and heavy equipment are not to be operated in the level spreader, because they can create surface indentations that concentrate flow.

Federal Aviation Administration Regulations

Applicability

Federal regulations Title 14 Part 77 requires establishes standards and notification for objects affecting navigable airspace. This includes any construction on Honolulu International Airport regardless of the height or location.

Agency

The notice must be submitted to the Federal Aviation Administration (FAA) (808) 541-1232. There are no fees associated with the notice and the notice form can be found at https://oeaaa.faa.gov/oeaaa/external/portal.jsp.

Requirements

Applicants must complete the "Notice of Proposed Construction or Alteration" form. In addition, the FAA may request the following:

- Scaled drawing showing location of alteration in relation to nearest runways. This may be marked up-Airport Layout Plan or Terminal Area sheet.
- Perpendicular distance of the proposed alteration to the nearest runway centerlines.
- Distance along centerline (actual or extended) from runway end to the perpendicular intercept point
- Ground elevation at the site of the proposed alteration
- Height of the proposed alteration including antennas or other appurtenances
- Accurate geodetic coordinates conforming to NAD 83
- Sketches, drawings, etc. showing the type of construction or alteration being proposed

Timeline

The notification must be submitted 30 days prior to construction. However, the FAA recommends that the notification be submitted 60 days prior to construction to allow time for conduct the aeronautical study.

FAA Determination

Once the FAA has completed the aeronautical study, they will make a determination about the project. "No Objection" means that the construction did not exceed the obstruction standards. "Conditional Determination" means that the proposed construction would be acceptable upon implementing measures such as marking and lighting. "Objectionable" means that the proposed construction is an air hazard.

Alternative Pavers

Description

Alternative pavers are permeable surfaces that can replace asphalt or concrete and can be used for driveways, parking lots, and walkways. Alternative pavers include gravel, cobbles, wood, mulch, brick, grass pavers, turf blocks, natural stone, pervious concrete, and porous asphalt. This reduces the amount of impervious surface and therefore reduces storm water runoff. Additionally, the pavers can act as a filter for the runoff to remove contaminants.

Practice

- The soil beneath the alternative pavers should have a permeability of at least 0.5 inch per hour.
- Storm water collected by the alternative pavers should be collected, diverted, and treated.
- Alternative pavers are effective when applied in combination with other BMPs such as bioretention and green parking.
- In industrial areas, the pavement should be at least 2 to 5 feet above the seasonally high ground water table and at least 100 feet away from drinking water wells.
- Inspect the pavers monthly to ensure water infiltration .
- Maintenance will involve at a minimum monthly sweeping of debris and sediments to prevent clogging.

Limitations

- Alternative pavers are not recommended for high-traffic volumes.
- A discharge pipe from the alternative pavement should be installed to the MS4 (with approval from DOTA) to allow for a bypass during large storm events.

Hawaii One Call Center

Applicability

Hawaii Revised Statutes, Chapter 269E, state that require that utility owners provide advanced warning to excavators before they begin digging. Therefore the Hawaii One Call Center was created to allow excavators to dial 1-866-423-7287 and reach the main utility companies.

Agency

Each individual utility company will be notified to deploy to the construction site to mark the location of their underground lines.

Requirements

The excavator must provide the Hawaii One Call Center with the following information:

- Contact information including name, phone number, and address
- What type of work is being done
- Who the work is being done for
- The location of the construction site including address and distance from nearest intersection

Once the Hawaii One Call Center has recorded the information, they will provide the excavator with a ticket number.

Timeline

Within two hours of receiving the ticket number, the Hawaii One Call Center will have notified all the utility owners of the proposed excavation. The utility owners will mobilize to the site within 2 to 5 days and mark the location of the underground lines with the appropriate color codes.

GREEN PARKING

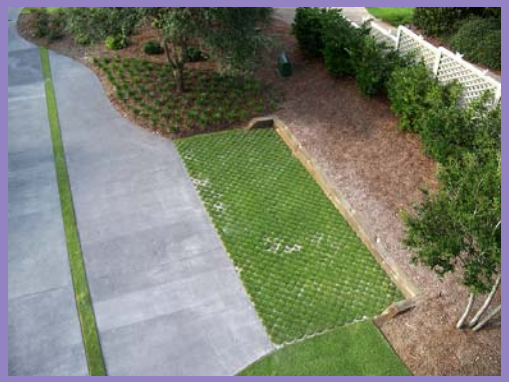
Description

Green parking refers to several techniques that applied in the right combination can reduce the total impervious groundcover; thereby reducing the quantity of storm water runoff. Green parking lot techniques include:

- Setting maximums for the number of parking lots created;
- Minimizing the dimensions of parking lot spaces;
- Utilizing alternative pavers in overflow parking areas;
- Using bioretention areas to treat storm water;
- Encouraging carpooling; and
- Providing economic incentives for structured parking.

Practice

- The parking lot should be designed by determining average parking demand instead of conventional parking requirements which uses the highest number of parking space requirements during peak season.
- Minimize the dimensions of parking spaces within the limitations of the local codes.
- Use alternative pavers such as gravel, cobbles, wood, mulch, brick, grass pavers, turf blocks, natural stone, pervious concrete, and porous asphalt.
- Consider the limitations to green parking such as applicability, cost, and maintenance.



Storm Water Treatment Best Management Practices

These BMPs are utilized after it has been determined that the storm water exiting a site has been contaminated. Therefore, the storm water must be treated before it reaches the receiving water.

Attachment D.3

Retrofit Action Plan

ACTION PLAN FOR RETROFITTING STRUCTURAL BEST MANAGEMENT PRACTICES

HONOLULU INTERNATIONAL AIRPORT
NPDES PERMIT NO. HI S000005

Prepared For:
DEPARTMENT OF TRANSPORTATION, AIRPORTS DIVISION
Honolulu International Airport
400 Rodgers Boulevard, Suite 700
Honolulu, Hawaii 96819-1880

January 2015

Version 1.0

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1.0 INTRODUCTION

The State of Hawaii Department of Transportation, Airports Division (DOTA) has completed this action plan for retrofitting permanent best management practices (BMPs) at the Honolulu International Airport (HNL) in accordance with the National Pollutant Discharge Elimination System (NPDES) Small Municipal Separate Storm Sewer System (MS4) permit HI S000005, Part D.1.f.(1)(iv). This plan includes the identification of specific retrofit projects, justification for their selection, and an implementation schedule.

1.1 Background

Previously, DOTA had completed a Retrofit Feasibility Study (Feasibility Study) dated August 2010, which identified and ranked potential permanent BMP projects at HNL. The Feasibility Study was prepared with information available at the time; however, there have been several new construction projects and rules that have been revealed. As a result, DOTA has re-evaluated projects from the initial Feasibility Study and included some new projects where applicable.

The initial projects from the Feasibility Study have been re-evaluated to include restrictions set by the Federal Aviation Administration (FAA) in regards to safety for active airports. FAA rules prohibit building wildlife habitats due to the hazards that birds may pose to aircraft safety. Specifically, the inclusion of green areas in construction projects has been prohibited since it could attract wildlife and lead to increased potential for bird strikes.

1.2 Performance Goal Summary

Storm water retrofitting involves the redesign and installation of storm water BMPs in areas of existing development to meet a retrofit goal. These goals were taken from the Feasibility Study and applied to the projects described in this plan (Table 1).

TABLE 1: RETROFIT PERFORMANCE GOALS

DESCRIPTION	PRIMARY PERFORMANCE GOALS
Pollutant Removal	Retrofits/BMPs shall achieve an overall reduction from existing, on-site total phosphorus loads for areas treated by retrofit/BMPs to the extent achievable. Provide retrofit/BMP designs that also address removal of sediment as well as oil and grease loads as priority pollutants.
Trap Trash and Floatables	Retrofits/BMPs shall achieve an overall reduction from existing, on-site trash and other floatables to the extent achievable.
Reduce Runoff Volumes	Retrofits shall promote infiltration and overall reduction in runoff volume to the extent achievable.
Education and Outreach	Provide outdoor learning and community outreach opportunities on DOTA land.
DESCRIPTION	**SECONDARY BENEFITS**
Quick Implementation Projects	Indentify quick implementation projects (constructed within 1 year) based on existing CIP projects, availability of funds, projects underway, etc.
Specific Problems	Identify retrofits for problem areas such as Ualena Street tenants, Baseyard sweeper rubbish, and the triturators.

2.0 IDENTIFICATION OF RETROFITS

The August 2010 Feasibility Study identified and evaluated potential retrofit projects within the property boundary of HNL. Since the completion of the Feasibility Study, several previously identified retrofit BMPs have been classified as not feasible based on safety concerns and current redevelopment activities at the airport as identified below:

- Bird Strike. FAA restricts any project that includes additional green areas since it has the potential to attract wildlife. Therefore, examples of BMP types that must now be excluded include, but are not limited to, constructed wetlands, large grassy swales, green roofs, planters, rain gardens, and bioretention systems. Projects that pose the threat of bird strike are now delisted from the Feasibility Study and are detailed in the table below.
- Project Site No Longer Available. The airport has undergone many changes since the development of the Feasibility Study in 2010 and several areas previously identified are now unavailable. Specifically, Ualena Street tenants have been asked to move to accommodate the new rail system and as a result the source of potential pollutants has been removed. The cell phone waiting lot (D10-7) has been closed and will be incorporated into another project.
- Tenant Space. It was discovered that DOTA needed to restrict retrofit projects to areas directly under DOTA control, which excludes tenant areas due to lease agreements. In order to manage storm water concerns at tenant spaces, tenants are required by DOTA to have annual storm water training, implement best management practices for their activities, and are regularly inspected for storm water concerns. Further, tenants are able to implement their own permanent BMPs as feasible. Therefore, projects for VIP Trans (D16-3), Rental Car Kalewa Street Lot (A1-1), and those on Ualena Street have been delisted.
- Potential Pollutants Contained. The Maintenance Baseyard was previously identified as an area for retrofit due to concerns about the management of their sweeper wastes. However, personnel have changed their practices and have developed another way to contain the pollutants. Specifically, a concrete pad with berms is used to dump the wastes and then they are transferred to a truck for disposal at the landfill. Any vehicle washing occurs at the airport wash racks. Therefore, since potential pollutants are adequately contained with these methods, the proposed retrofit has been delisted.

2.1 Updated List of Retrofit BMPs

The Feasibility Study used a systematic approach to rank potential projects. A desktop analysis identified 84 potential sites via mapping technologies. The potential locations were then inspected by field crews and a list of the 24 potential retrofits identified. Based on the considerations described in the previous section as well as the new development projects currently underway at the airport, DOTA has revised the list of retrofits in the table below. These will be implemented at the airport to reduce the discharge of potential pollutants and meet the performance goals. The entire Feasibility Study can be found online at: http://hidot.hawaii.gov/airports/doing-business/engineering/environmental/construction-site-runoff-control-program/.

TABLE 2: UPDATED LIST OF RETROFIT BMP PROJECTS

PROJECT DESCRIPTION	BMP TYPE
Various Storm Drains (Table 5)	Filtration Products
Triturator	Redesign for Containment
A9-3 Lagoon Drive Parking Lot	Permeable Pavers
D10-1 Access "A" Canal	Canal Stabilization
D14-1 Kaloaloa Canal	Canal Stabilization
New Projects	
New Employee Parking Lot	Pervious Concrete
South Ramp Fuel Rack	Oil Water Separator
New Hawaiian Hangar	CDS Units
Widening of Taxiways G&L, Phase I	CDS Units
Diamond Head Site Improvement	CDS Units
Diamond Head Commuter Terminal	CDS Units
CONRAC Phase 2B (Rental Car Facility)	Detention Basin
New Mauka Concourse	Detention Basin

2.1.1 Storm Drain Retrofits

The Feasibility Study included a list of storm drains ranked based on the amount of debris removed by the maintenance contractor. This plan will include the implementation of those 25 drains ranked as a "5," which means that they have accumulated the greatest amounts of debris. Maps of drain locations have been included in Appendix A and specific map numbers are included in the table below. Note: EIDs 4580, 7553, and 7513 were removed since they are not drain inlets. EID 9937 and 4364 were added due to their proximity to the triturators.

TABLE 3: STORM DRAIN INLETS

BASIN	EID	MAP SHEET
D15	4598	2
A2	4632	3
A6	4703	6
A6	5748	6
B9	5522	15
B10	4140	15
B10	9937	15
D2	5096	17
D4	5121	17
D4	5123	17
D4	5132	17
D4	7466	17
D4	7520	17
D4	7525	17
D6	7465	17
D6	7534	17

BASIN	EID	MAP SHEET
D6	10197	17
D6	10217	17
D6	10255	17
D17	5147	17
D10	4366	24
D10	4319	25
D10	4336	25
D10	4364	25
D10	10227	25

2.1.2 Triturator

HNL has two triturator units that are designed to capture sanitary waste from aircraft and deposit it into the City and County of Honolulu sanitary sewer system. The current configuration of the triturators allows for any spilled materials to runoff to nearby storm drains. A proposed retrofit of these two stations would include permanent berms around each triturator pit so that spills would pool in the area rather than flow. This design would be in addition to the temporary BMPs currently installed in the nearby drains and training provided to lavatory truck drivers.

2.1.3 Lagoon Drive Parking Lot (A9-3)

Although the design for the Lagoon Drive parking lot originally included bioretention, the retrofit could still be incorporated with only the permeable pavers. This would decrease the impervious area at the airport and provide a good public education tool since this area is not within the secured area.

2.1.4 Canal Stabilization (D10-1, D14-1)

There has been some erosion noted within the Kaloaloa Canal as well as the Access “A” Canal. Stabilizing these canals would prevent the discharge of sediment from the drainageways to Keehi Lagoon.

2.1.5 New Employee Parking Lot

The design included pervious concrete and bioswales in the new employee parking lot construction to minimize the impervious area being added. Additionally, since many employees will use the lot on a regular basis, it will provide an excellent opportunity for public education.

2.1.6 South Ramp Fuel Rack

The South Ramp Fuel Rack includes an oil water separator (OWS) that will be effective in trapping any fuel that may spill during operations at the site.

2.1.7 CDS Units

The new Hawaiian Airlines Hangar, Widening Taxiways G&L, and the Diamond Head Site Improvements projects include continuous deflective separation (CDS) units that will aid in removing particles such as sediment and trash as well as oil and grease from the storm water runoff.

2.1.8 Detention Basins

The designs have identified detention basins as via alternative permanent BMP that will not attract wildlife. These systems will also save on the limited space available at the airport. They are designed to capture and hold the storm water and allow it to infiltrate into the ground. This method will effectively capture all potential pollutants that may be generated on a site.

2.2 Retrofit Ranking

The 2010 Feasibility Study had previously used a ranking system which evaluated pounds of total phosphorous (TP) removed, cost effectiveness (per pound of TP treated), runoff reduction, public education, available for quick implementation, addressing a specific problem, maintenance burden, permitting issues, and site constraints. However, the new list of retrofit projects has not been ranked because they will all be implemented on a timeline that is more heavily influenced by the airport construction schedule.

3.0 ACTION ITEMS

These specific actions will be conducted in order to implement the identified retrofit projects. These steps will include planning, funding, designing, managing the installation, and conducting or overseeing long term maintenance for the retrofit BMPs. Per the NPDES permit, at a minimum two (2) retrofit projects will be completed per year for five (5) years and the status reported in the annual report.

3.1 Planning, Funding, and Designing

The seven new projects identified by this plan have already been planned and funded. They are currently either being designed or under construction. The five projects that were included from the 2010 Feasibility Study would need to be budgeted. Then, when the budget is secured, an engineering designer can prepare the construction plans.

3.2 Installation

Once construction plans have been created and approved, construction contractors will be retained. The installation will be overseen by the DOTA Environmental Section per the Storm Water Management Program Plan (SWMPP) Section C and D.

3.3 Long Term Maintenance

Contractors will be required to provide an Operations and Maintenance (O&M) manual for the permanent BMPs when they are constructed. This manual will detail the required maintenance frequency and procedures. Then, the District Maintenance Section will be responsible for performing the maintenance or issuing a contract for the required maintenance. The DOTA Environmental Section will keep the maintenance records as a part of the annual NPDES report.

TABLE 5: RETROFIT SCHEDULE*

Retrofit BMP Project Description	BMP Type	Year 1	Year 2	Year 3	Year 4	Year 5
		2015	2016	2017	2018	2019
New Employee Parking Lot	Pervious Concrete	X				
South Ramp Fuel Rack	Oil Water Separator	X				
New Hawaiian Hangar	CDS Units		X			
Widening of Taxiways G&L, Phase I	CDS Units		X			
Diamond Head Site Improvement	CDS Units			X		
Diamond Head Commuter Terminal	CDS Units			X		
CONRAC Phase 2B (Rental Car Facility)	Detention Basin					X
New Mauka Concourse	Detention Basin					X
Various Storm Drains (Table 5)	Filtration Products				X**	
D10-1 Access "A" Canal	Canal Stabilization				X	
D14-1 Kaloaloa Canal	Canal Stabilization	To be determined				
Triturator	Redesign for Containment	To be determined				
A9-3 Lagoon Drive Parking Lot	Permeable Pavers	To be determined				

* Based on construction start dates and may be subject to change. Timeframes are based on calendar years.
** Storm drain retrofits may also be included as an addition to other projects and will be subject to their construction schedule. At least one of the storm drain retrofits will be completed by this date.

4.0 REFERENCES

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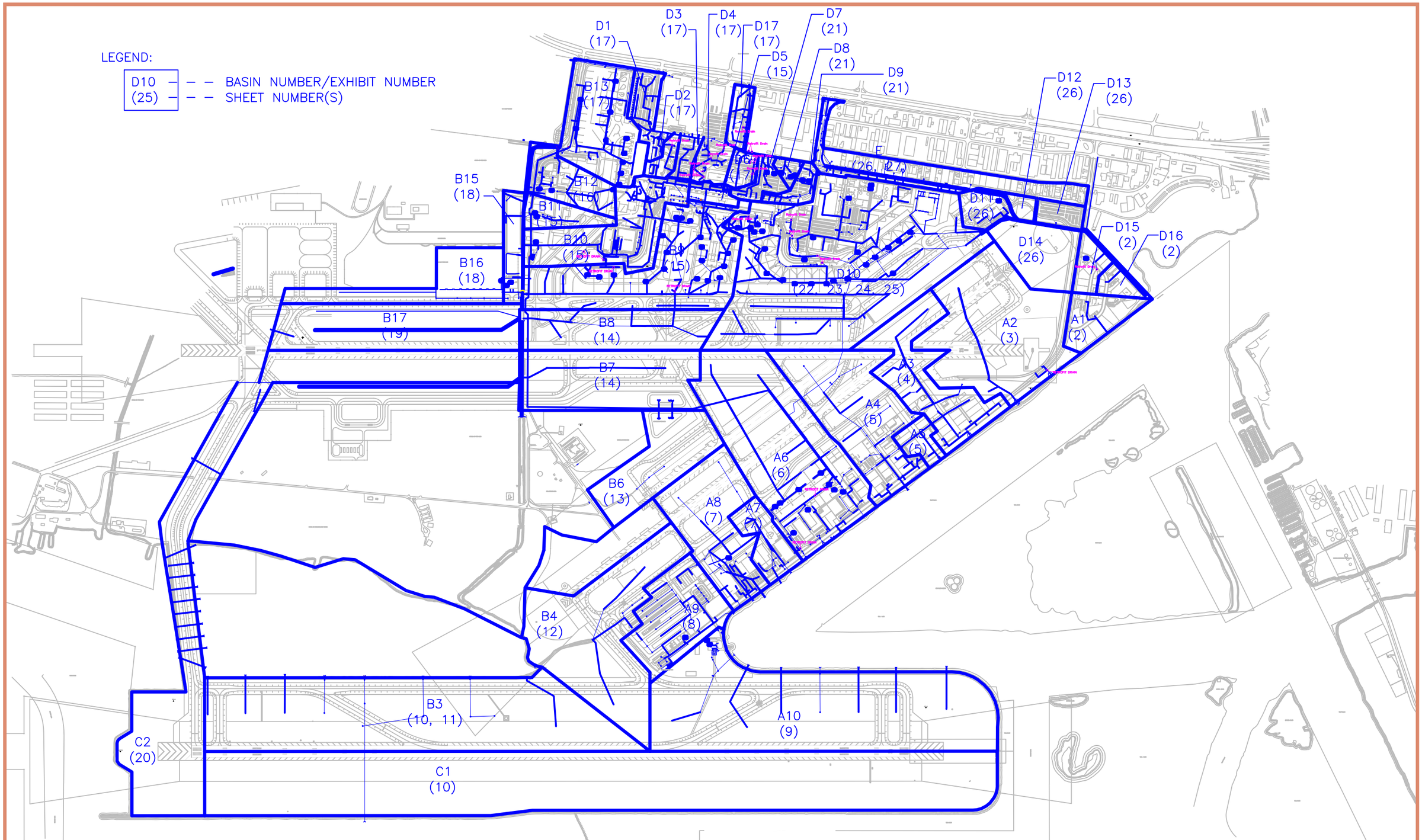
APPENDIX A

Storm Drain Retrofit Maps



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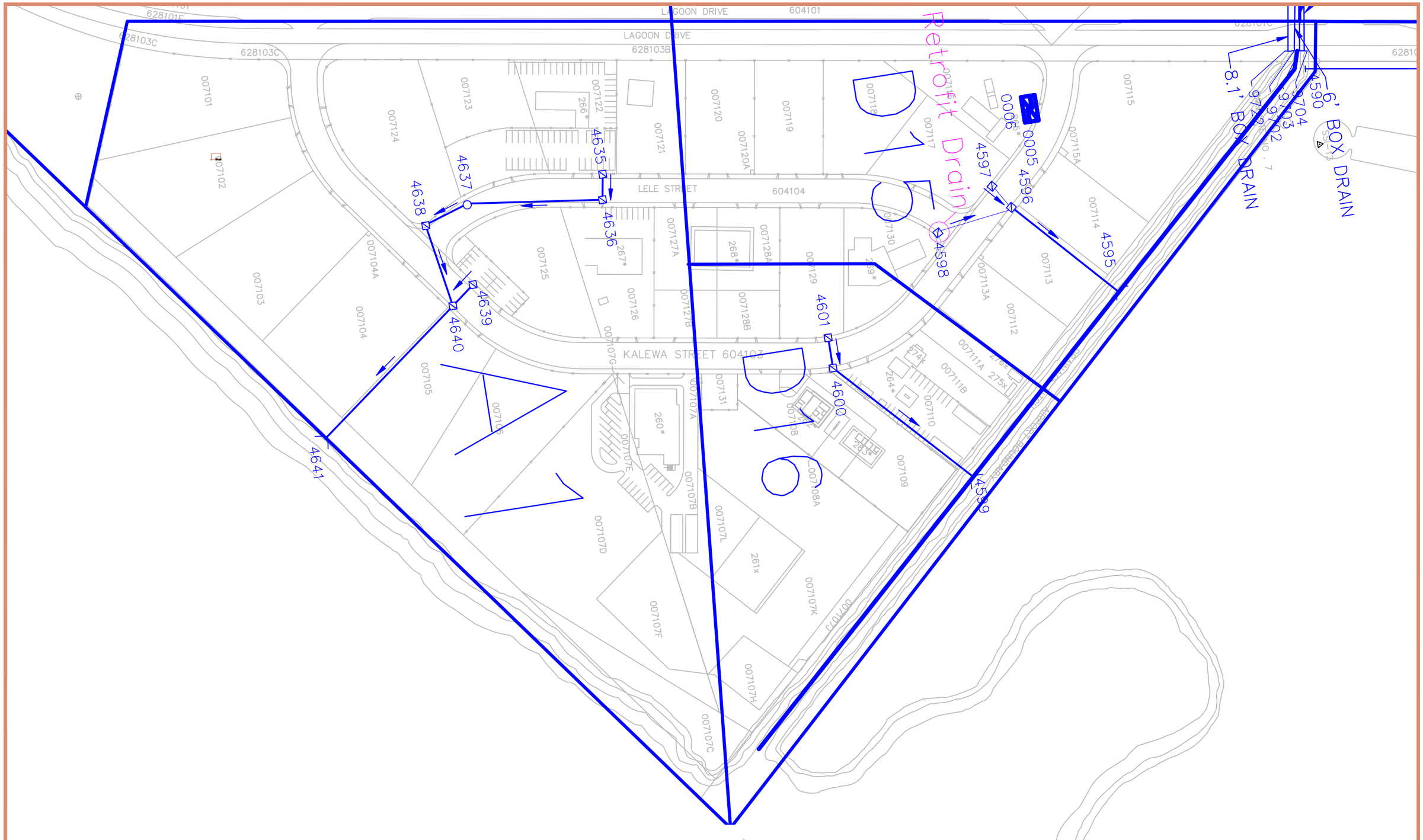

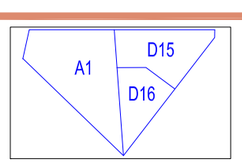

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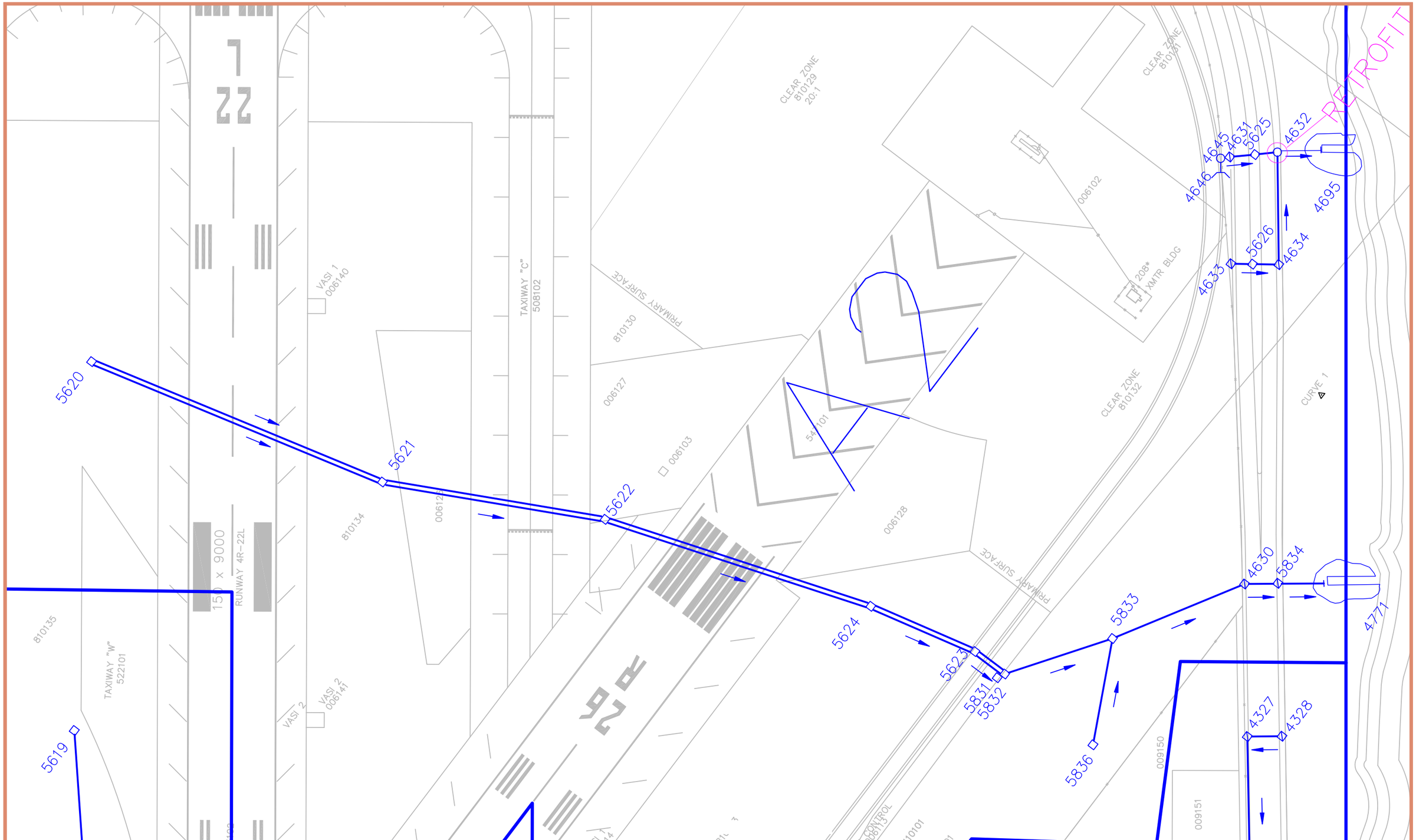

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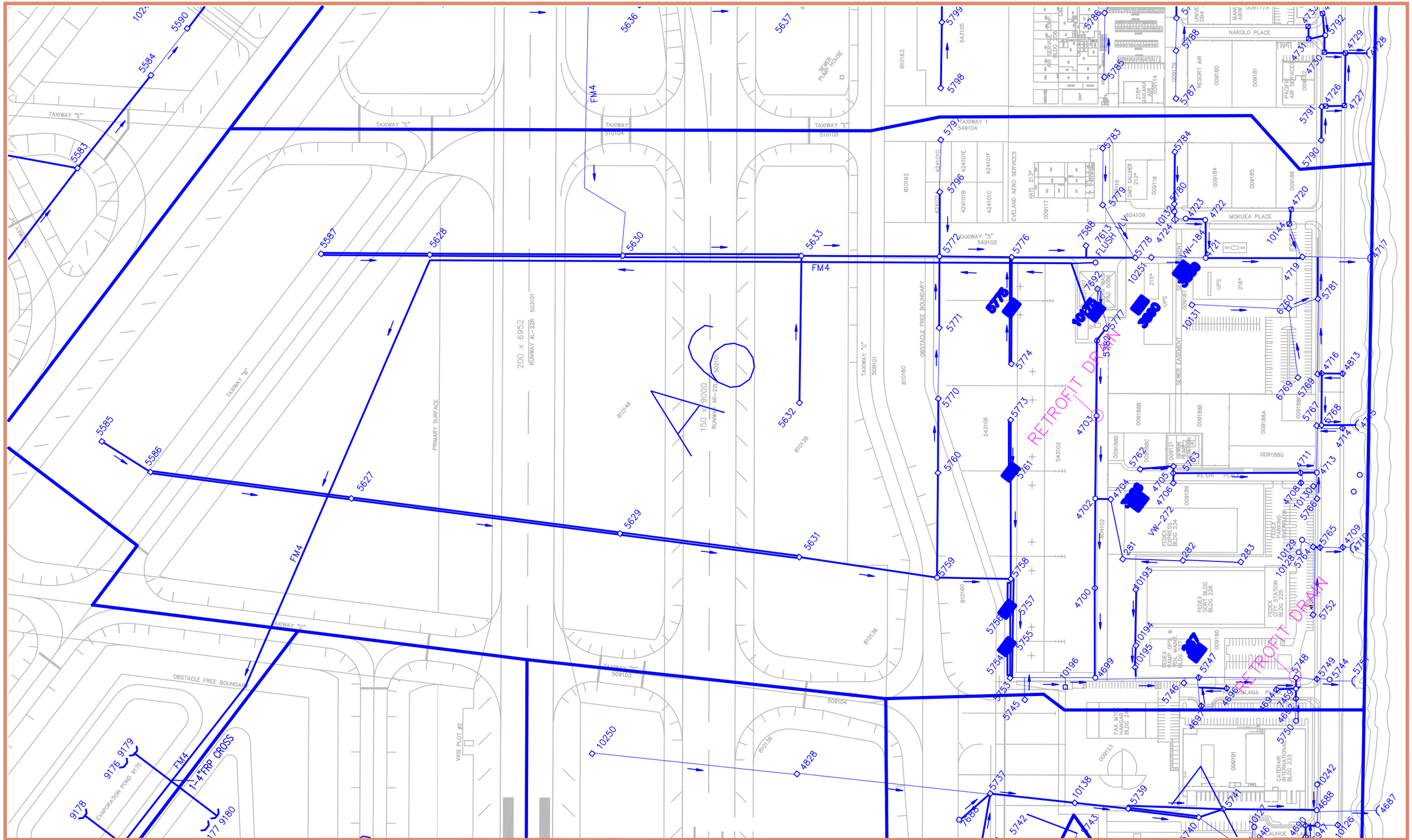

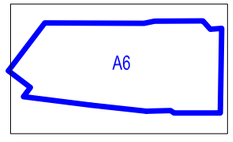

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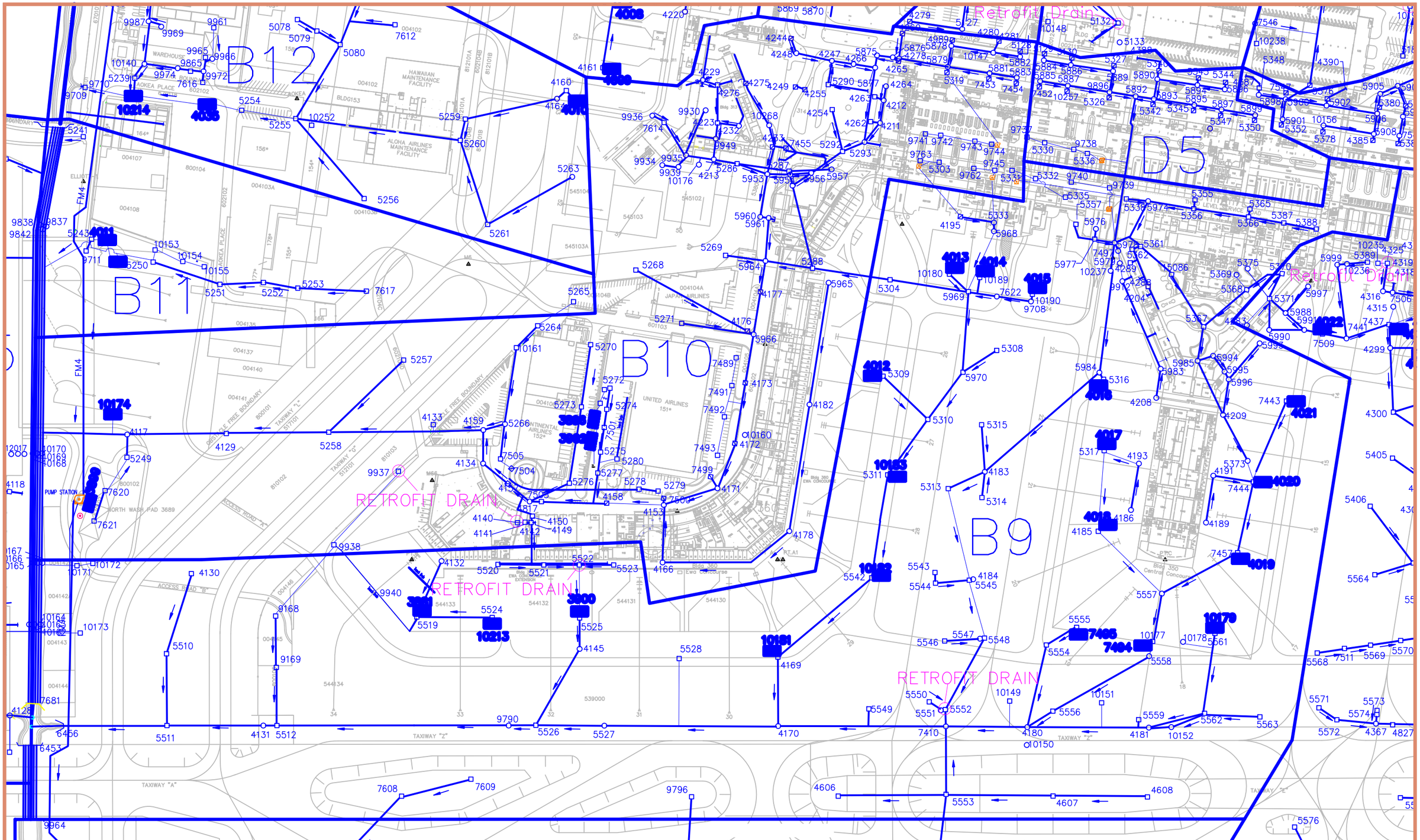

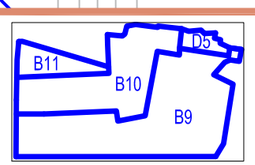

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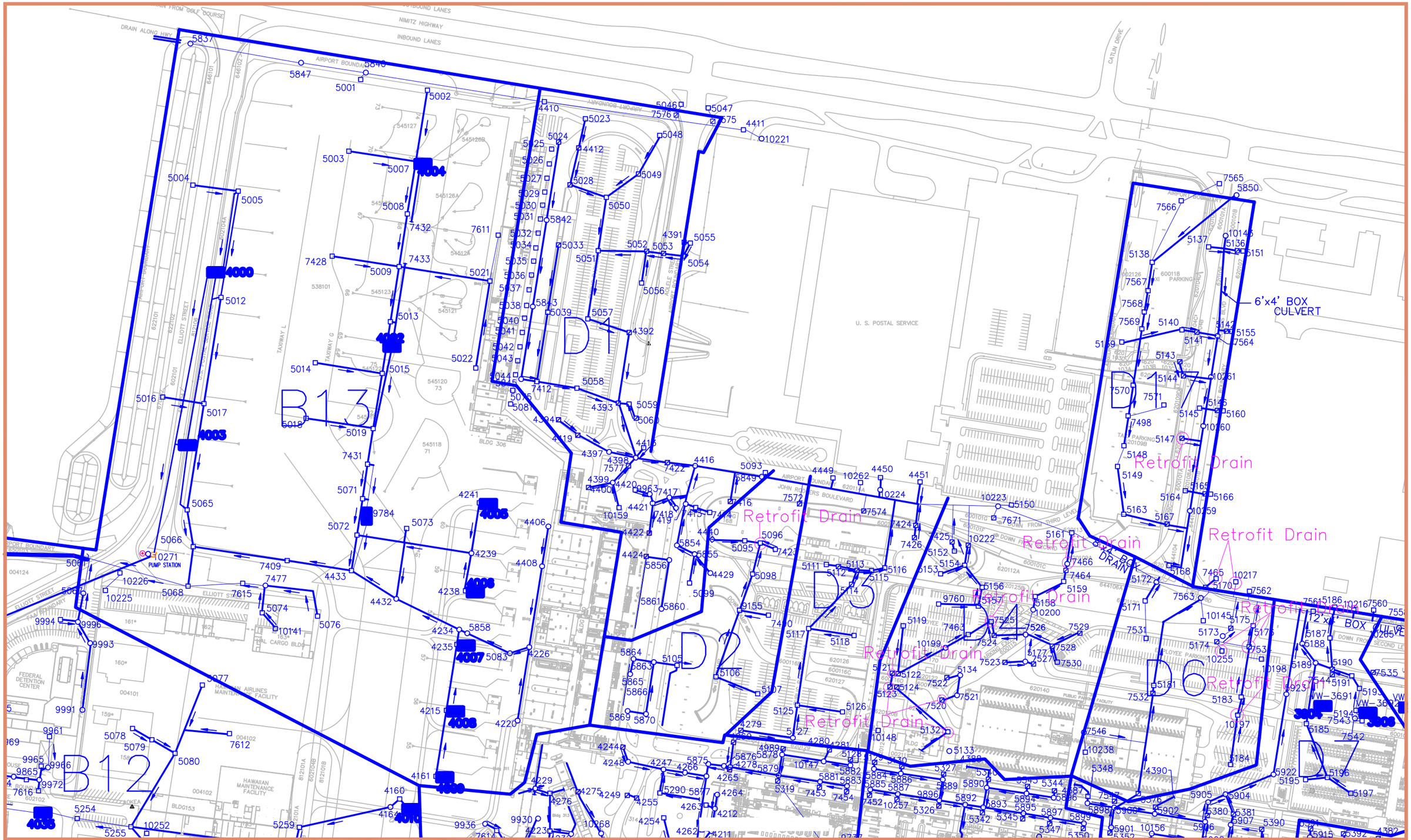

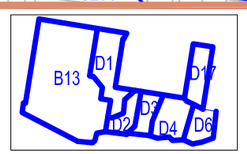

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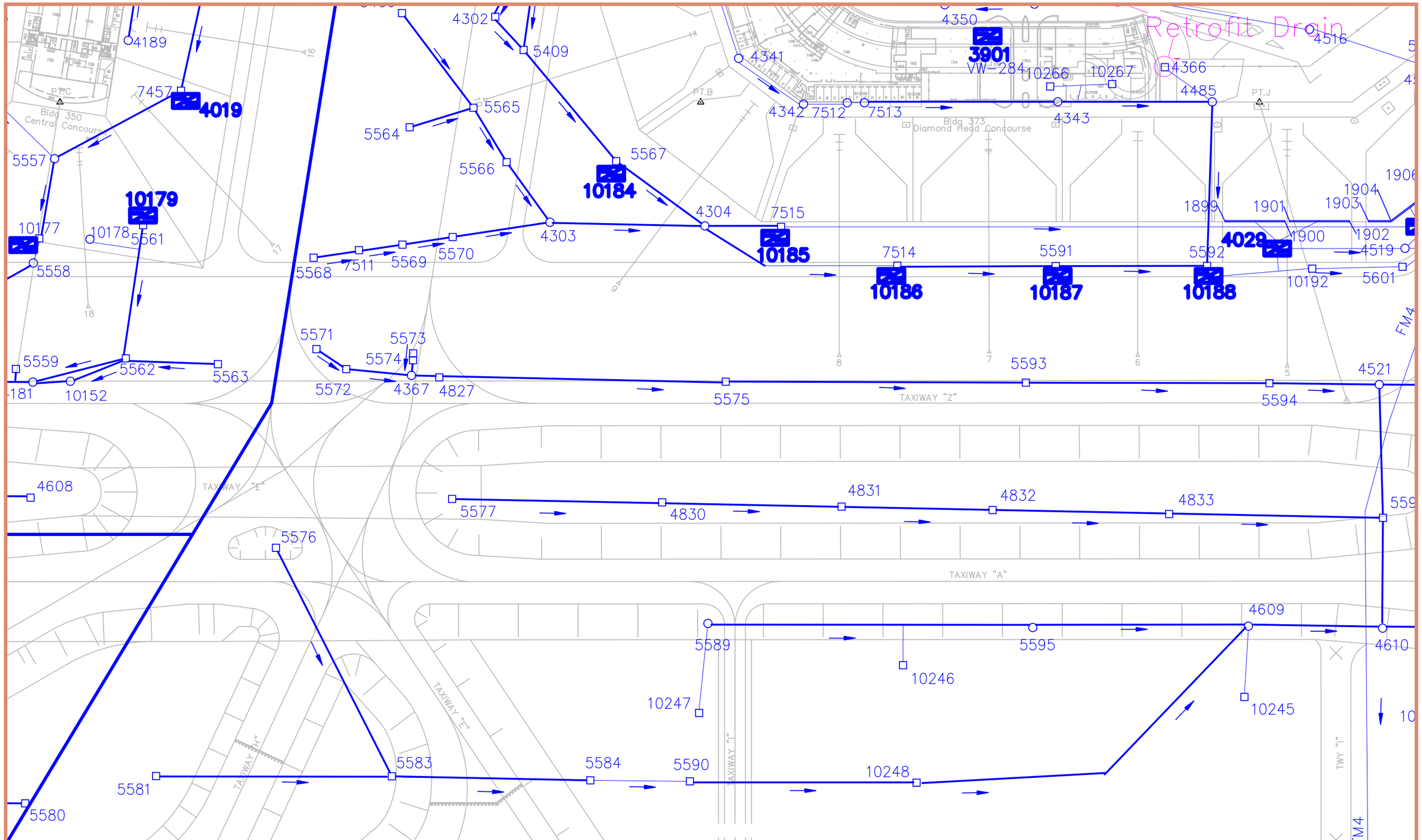

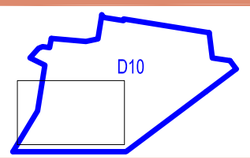

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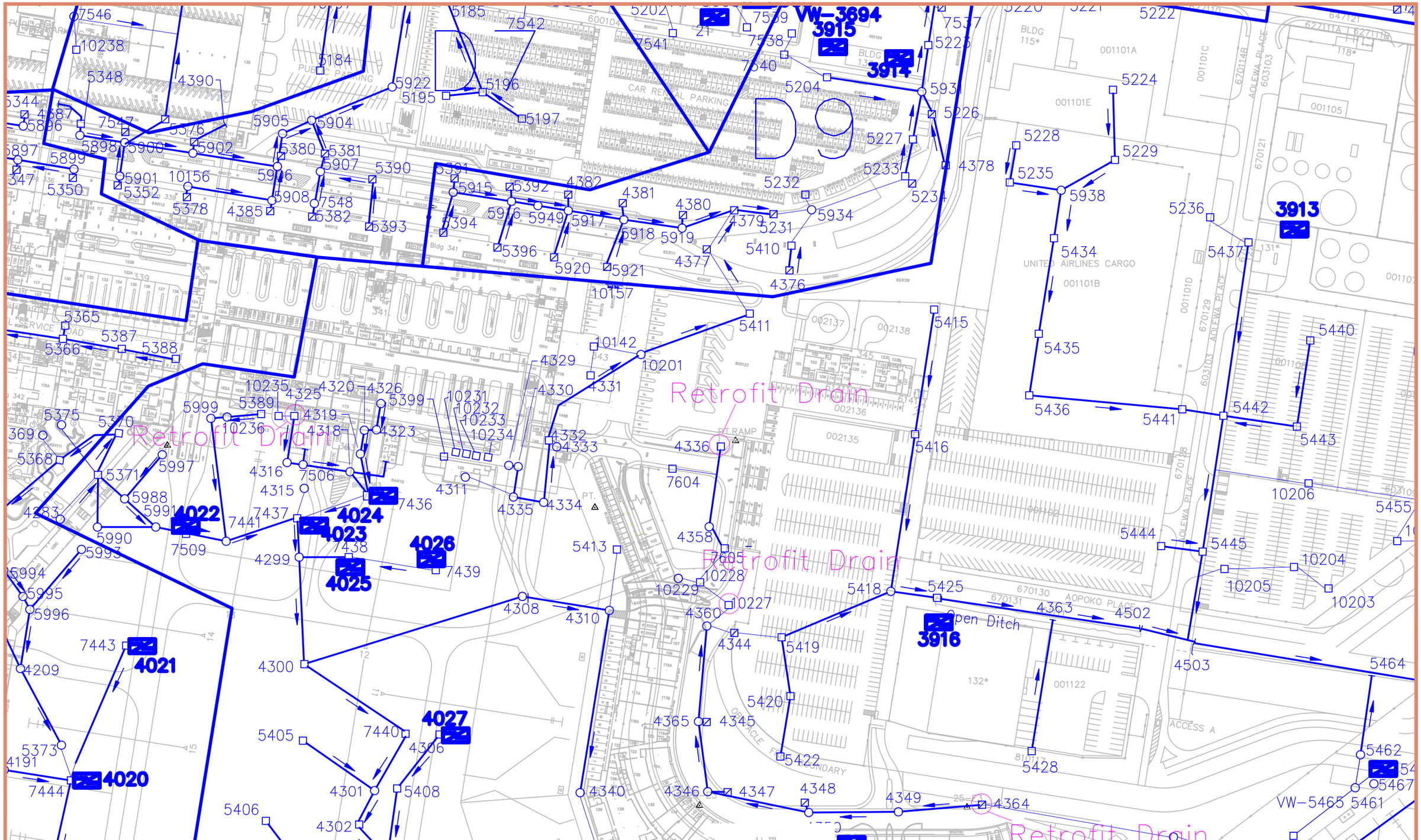

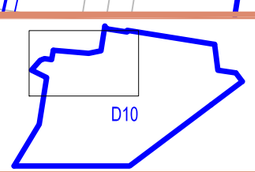

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